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CATALOGUE 1977-1978

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MONTEREY
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NAVAL POSTGRADUATE SCHOOL
EXCELLENCE THROUGH EDUCATION

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIFORNIA

MISSION

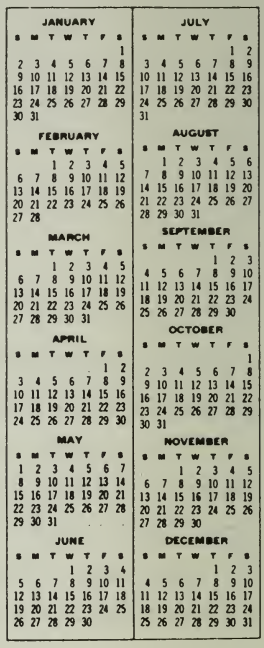
The Secretary of the Navy has defined the mission of the Naval Postgraduate School as follows:

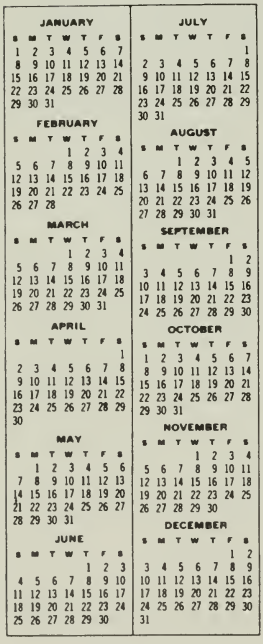
"To conduct and direct the Advanced Education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet he needs of the Naval Service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence."

CALENDAR FOR 1977-78 ACADEMIC YEAR

1977

Registration	Monday, 27 June
Fourth of July (holiday)	Monday, 4 July
Summer Quarter begins	Tuesday, 5 July
Refresher Course begins	Monday, 15 August
Labor Day (holiday)	Monday, 5 September
Examination Week for Summer Quarter	19-22 September
Summer Quarter ends	Thursday, 22 September
Graduation	Thursday, 22 September
Registration	Monday, 26 September
Fall Quarter begins	Monday, 3 October
Columbus Day (holiday)	Monday, 10 October
Veterans Day (holiday)	Monday, 24 October
Thanksgiving Day (holiday)	Thursday, 24 November
Examination Week for Fall Quarter	16-20 December
Fall Quarter ends	Tuesday, 20 December
Graduation	Monday, 19 December
Christmas (holiday)	Monday, 26 December





1978

Registration	Tuesday, 3 January
Winter Quarter begins	Monday, 9 January
Washington's Birthday (holiday)	Monday, 20 February
Refresher Course begins	Tuesday, 21 February
Registration	Monday, 27 March
Examination Week for Winter Quarter	27-30 March
Winter Quarter ends	Thursday, 30 March
Graduation	Thursday, 30 March
Spring Quarter begins	Monday, 3 April
Memorial Day (holiday)	Monday, 29 May
Examination Week for Spring Quarter	19-22 June
Spring Quarter ends	Thursday, 22 June
Graduation	Thursday, 22 June
Registration	Monday, 3 July
Fourth of July (holiday)	Tuesday, 4 July
Summer Quarter begins	Monday, 10 July
Refresher Course begins	Monday, 14 August
Labor Day (holiday)	Monday, 4 September
Registration	Monday, 25 September
Examination Week for Summer Quarter	25-28 September
Summer Quarter ends	Thursday, 28 September
Graduation	Thursday, 28 September
Fall Quarter begins	Monday, 2 October

Superintendent

ISHAM WISEMAN LINDER
B.S., U.S. Naval Academy, 1946
M.S.E.E., Naval Postgraduate School, 1956
Ph.D., University of California at Berkeley, 1961

Academic Dean

JACK RAYMOND BORSTING
B.A., Oregon State University, 1951;
M.A., University of Oregon, 1952; Ph.D., 1959

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DEAN OF ACADEMIC PLANNING and DEAN OF INFORMATION AND POLICY SCIENCES, DAVID ALAN SCHRADY: B.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

DEAN OF ACADEMIC ADMINISTRATION, ABRAHAM SHEINGOLD; B.S., College of the City of New York, 1936; M.S., 1937.

REGISTRAR, EDITH JEAN WARRINER; B.A., Occidental College, 1947.

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Admiral Cato D. Glover, Jr.
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Vice Admiral Harold T. Deutermann
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HISTORY

The Naval Postgraduate School is in its 69th year of providing advanced education for commissioned officers of the United States Navy. When it was established at Annapolis on 9 June 1909, only ten officers made up the class, three professors formed the faculty, and marine engineering was the only curriculum. It was called the Postgraduate Department of the U.S. Naval Academy.

The school suspended operations during World War I. When classes resumed in 1919, mechanical and electrical engineering were added to the course of instruction. Later, ordnance engineering, radio engineering, aerological engineering and aeronautical engineering were introduced as the Navy continued to recognize its need for officers with technical knowledge. The postgraduate department was renamed the United States Naval Postgraduate School, but still operated as a part of the Naval Academy.

In 1927 the General Line Curriculum was established to provide instruction which would acquaint junior line officers with modern developments within the Navy, and to broaden their professional knowledge for future command at sea. It remained an integral part of the school until World War II, when the general line students returned to the fleet. Enrollment in the other curricula continued to increase during the war years as the school grew to meet the needs of the Navy. After the 1945 armistice, the Navy began plans to move the Postgraduate School away from Annapolis and to improve its professional status. The post-war period also saw the General Line School reestablished, this time at Newport, Rhode Island, and at Monterey, California. Between 1945 and 1948, Congress established the school as a separate activity under its own superintendent, created the office of academic dean, granted the superintendent the authority to award the bachelor's, master's, and doctor's degrees, and approved Monterey as the future home of the school.

After purchasing the former Del Monte Hotel and surrounding acreage, the Naval Postgraduate School was officially established on the West Coast on 22 December 1951. Five years later the Navy Managment School joined the General Line School as a component of the Postgraduate School, and for the first time a Bachelor of Science curriculum was offered to selected officers who had not completed their undergraduate education. A further need for baccalaureate courses resulted in the inauguration of the Bachelor of Arts curriculum in 1961.

A year later the Chief of Naval Personnel authorized a major internal reorganization of the school. The management, engineering and general line schools merged, in effect making the Naval Postgraduate School a naval university, unified in policy, procedure and purpose.

In addition to its Naval officer students, the School has, since 1947, been enrolling officers from the United States Army, Air Force, Coast Guard and Marine Corps as well as Military officers from Allied countries. These officers have constituted about 25% of the student body for many years. Effective in 1975, civilian employees of the United States Government have started to be enrolled as regular students.

Since 1946 the School has awarded 6,017 bachelor's degrees, 7,701 master's degrees, 235 engineer's degrees, and 84 doctoral degrees. At the present time the total emphasis is on graduate level programs.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are a Provost/Academic Dean who is the senior member of the civilian faculty; and two captains of the line — a Director of Programs, and a Director of Military Operations and Logistics.

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices and

Academic Departments. The former are staffed by naval officers and civilian faculty members whose primary functions are threefold: (1) academic counseling and military supervision of officer students; (2) curriculum development and management to insure attainment of professional and academic objectives; and (3) liaison with curricular sponsor representatives. Officer students in each curricula group pursue similar or closely related curricula.

Officer students are grouped into the following curricular program areas:

Administrative Science
Aeronautical Engineering
Computer Technology
Electronics and Communications
Environmental Sciences
Naval Engineering
Naval Intelligence/National Security Affairs
Operations Research/Systems Analysis
Weapons Engineering/ASW

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into eleven academic departments and two interdisciplinary groups:

Administrative Sciences
Aeronautics
ASW Group
Computer Science
Electrical Engineering
Electronic Warfare Group
Mathematics
Mechanical Engineering
Meteorology
National Security Affairs
Oceanography
Operations Research
Physics and Chemistry

Over five-sixths of the teaching staff are civilians of varying professional rank and the remainder military officers.

The Academic Program organization described is supervised by the Director of Programs, the Dean of Information and Policy Sciences, and the Dean of Science and Engineering who collaborate to share jointly the responsibilities for planning, conduct and administration of the several educational programs.

The close tie between elements of this dual organization is further typified by the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula — the Navy's needs being the responsibility of the Curricular Officer, and academic soundness being the responsibility of the Academic Associate.

Logistic service support is rendered by conventional departments such as Supply and Public Works grouped organizationally under a Director of Military Operations and Logistics. Certain other officers such as the Comptroller and Civilian Personnel Officer are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fishermen's Wharf. The site of the School is the former luxury Del Monte Hotel of pre-World War II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research and a nearby laboratory and recreation area. The total campus covers approximately 600 acres.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its Spanish architecture.

Most of the academic classrooms, laboratories, and offices are located in Spanagel, Bullard, Halligan, Root and Ingersoll Halls. The newest building is the 400,000 volume Dudley Knox Li-

brary which was completed early in 1972. Adjacent to the main academic buildings is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the officers of the Postgraduate School.

LaMesa Village, located 3 miles from the School, consists of former Wherry Housing, Capehart Housing and Townhouses. There are a total of 877 units of public quarters for officer students. An elementary school is located within the housing area. Limited housing for single students is available in the BOQ located on the main campus in Herrmann Hall.

Student services include a campus branch of Bank of America, Navy-Federal Credit Union, U.S. Post Office, Student Mail Center, Navy Exchange and a child care center. A large commissary is located at Fort Ord and is available to Navy personnel.

Medical facilities include a Dispensary, supported by the U.S. Army Hospital at Fort Ord (7 miles away), and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

The center of campus social activity is the Commissioned Officers and Faculty Club, located in the old hotel building. There are many beautifully appointed rooms, just as they were at the turn of the century, including a ballroom and Open Mess. Two beautiful chapels are located on the main campus.

Student wives and wives of allied officers are active in the Officer Student Wives Club, the International Wives Club, as well as a Little Theater group which puts on three productions a year.

Recreational facilities include a swimming pool, an 18-hole golf course, putting green, tennis courts, ping pong and badminton courts, basketball and volley ball courts, a softball diamond, picnic grounds, bowling lanes, driving range, archery range, and gymnasium. Included in the many activities which participate in competition off campus are Ladies Golf Association, Mens Golf Association, Soccer Club, Rugby Club, Lacross Club, Ski Club, Karate Club, Tennis Club, and basketball and softball teams. The School also has a very active Military Amateur Radio Station and a Navy Flying Club.

Personnel assigned to the Postgraduate School have a very active Sailing Association open to sponsors and their dependents as well as members of the faculty. Sailing conditions are among the finest on the West Coast with excellent weather prevailing from February through November. The School's recreation department schedules the 3 Shields Class Racing Sloops, 2 Santana-22s and 1 Columbia 22 on a first-come first-served basis. Classes for beginners and advanced sailing enthusiasts are conducted twice a year, following the January and July inputs. The School works closely with civilian yacht clubs to coordinate many sailing events throughout the year and, in addition, hosts the annual Navy West Coast Match racing championships.

TEXTBOOKS

The Naval Postgraduate School operates a bookstore under the Navy Exchange system. It stocks all required textbooks and related school supplies. Students are required to purchase their books either from the school or local bookstores, or from other students.

Prospective students desiring a copy of the Postgraduate School Catalogue may request one by sending a check for $1.35 to: Naval Exchange Bookstore, Naval Postgraduate School, Monterey, California 93940.

ADMISSIONS PROCEDURES

U.S. NAVAL OFFICERS

U.S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to

OPNAV Notice 1520, Subject: Postgraduate Educational Programs, which is published annually by the Chief of Naval Operations. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Chief of Naval Personnel to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by a BUPERS Notice at the earliest feasible date after the meeting of the selection board, or by official correspondence.

OTHER U.S. MILITARY OFFICERS

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U.S. Marine Corps, or the Commandant U.S. Coast Guard, as appropriate.

ALLIED COUNTRY MILITARY OFFICERS

Military officers from Allied countries may be admitted to most curricula. Their admission is subject to availability of quotas assigned to each country. The procedures for application are contained in OPNAV INSTRUCTION 4950.1E. Correspondence must be processed through normal channels; requests from individual officers should not be sent directly to the Naval Postgraduate School. In addition to fluency in English, candidates must satisfy the academic standards for each curriculum as described in this catalogue.

CIVILIAN EMPLOYEES OF U.S. GOVERNMENT

Civilian employees of the United States may be admitted for study upon request and sponsorship by a federal activity. They do not need to pursue the curricula designed for officer students as described in this catalogue but instead will determine the combination and sequence of courses that will best meet their educational needs.

Requests for admission should be in letter form, indicating the academic area of interest and degree intentions, and enclosing official transcripts of all previous college work. GRE and/or GMAT test scores are not required but will be considered when included in the submission.

Requests for admission or questions regarding admission procedures should be directed to the Dean of Academic Administration, Code 014, Naval Postgraduate School, Monterey, CA 93940; or telephone (408) 646-2392 or Autovon 878-2392.

TRANSFER OF CREDITS

Upon entry to the Naval Postgraduate School, each student's prior academic record will be evaluated for possible transfer of credit. A course given here may be validated when a course covering the same material has been taken previously; no credit is awarded here in this case, but the sutdent is exempt from taking the course. All graduate level courses taken after completion of the baccalaureate degree may be accepted for credit; graduate level courses certified to be in excess of requirements for the baccalaureate degree and taken in the last term before award of the baccalaureate may be accepted for Graduate Credit under certain circumstances. Students are encouraged to seek validation or credit for courses by taking a departmental examination. This allows the student to utilize knowledge gained through self-study, experience, or service related courses.

As a consequence of its policy on transfer of credit, the School requires only 12 quarter hours in residency for the master's degree. Questions on transfer credit may be directed to the Dean of Academic Administration by letter or AUTOVON 878-2391.

PREPARATORY COURSES

After notification of selection, officers are encouraged to write to the Superintendent (Code 500), Naval Postgraduate School, Monterey, CA 93940, for counseling on available self-study mathematics, physics and other preparatory courses. Correspondence should indicate curriculum number, expected entry date at NPS, and year in which similar courses were previously taken. Officers are urged to undertake such a self-study program.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. This authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School was accredited in 1962 as a full member of the Western Association of Schools and Colleges. Initial accreditation as an associate member was given in 1955. Specific engineering curricula have been accredited by the Engineers' Council for Professional Development (ECPD) since 1949.

The Postgraduate School operates under a quarter system, with each term of instruction lasting 12 weeks. The last week of each quarter is set aside for examinations. In addition, there are two 2-week recesses during the academic year, one over Christmas and one during June-July.

Students' performance is evaluated on the basis of a quality point number assigned to the letter grade achieved in a course as follows:

Performance	*Grade*	*Point Value*
Excellent	A	4
	A−	3.7
	B+	3.3
	B	3
	B−	2.7
	C+	2.3
	C	2
	C−	1.7
	D+	1.3
	D	1
Failing	X	0
Incomplete	I	—
Withdrew Passing	W	—
Withdrew Failing	WX	0
Nongraded	N	—
Pass	P	—
Fail	F	—

Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. Hours earned by the grade of P shall be counted toward fulfilling course hours specified by the degree requirements.

A grade of Incomplete (I), if not removed within twelve weeks following the end of the term for which it was received, will be replaced by the grade "X". Exceptions must be individually approved by the Academic Council.

When the quarter hours value of a course is multiplied by the quality point number of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the quarter hour value of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours. Satisfactory academic proficiency at the Naval Postgraduate School has been established at a QPR of 2.0 for all courses of a curriculum.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowl-

edge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for this purpose between classes.

The courses listed in this Catalogue are assigned a level of academic credit by the numbers assigned.

0001-0999 No credit
1000-1999 Lower division credit
2000-2999 Upper division credit
3000-3999 Upper division or graduate credit
4000-4999 Graduate credit

The two numbers in parenthesis (separated by a hyphens) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned credit value of 4 quarter hours.

ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include Eta Kappa Nu, Sigma Xi, Tau Beta Pi, as well as ACM (Association for Computing Machinery), AIAA (American Institute of Aeronautics and Astronautics), AMS (American Meterological Society, ASME (American Society of Mechanical Engineers), ASNE (American Society of Naval Engineers), IEEE (Institute of Electrical and Electronics Engineers, Inc.), ORSA (Operations Research Society of America), and the Marine Technology Society.

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 3.65, or higher, while carrying a minimum academic load of 12 quarter hours.

GRADUATION WITH HONORS. The award of the Master of Science degree may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and is in the upper 10% of the graduating class. The award of a Bachelor's degree may be made "Cum Laude" when a student completes the degree requirements with a minimum of 60-quarter hours in residence and is in the upper 5% of the graduating class.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma Xi, an honorary society founded to recognized excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J.C. WOELFEL AWARD. This award is given annually to the United States Naval Officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

W. RANDOLPH CHURCH AWARD. This award is given annually to a student on the basis of his performance in mathematics courses. The criteria for selection will include evidence of initiative, scholarly attitude and mathematical

maturity. The student need not be a mathematics major, nor must he be a graduate at the time of presentation.

NAVAL ELECTRONIC SYSTEMS COMMAND AWARD IN ELECTRONICS ENGINEERING. This award will be given semiannually to a Master of Science candidate in the Advanced Electronics Engineering Program who has a most outstanding academic record and whose qualities indicate an outstanding military officer.

NAVY LEAGUE OF MONTEREY AWARD FOR ACADEMIC IMPROVEMENT. This award is presented quarterly to the graduating Navy, Marine Corps, or Coast Guard student (less Ph.D. candidates) who has demonstrated outstanding academic achievement during his enrollment at NPS. The award is made primarily on the basis of the student's academic improvement.

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION AWARDS. Up to three of these awards may be presented each quarter to graduates of the Communications and Engineering Electronics curricula who have demonstrated the highest scholastic achievement.

NAVAL SEA SYSTEMS COMMAND AWARD IN NAVAL ENGINEERING. This award affords recognition to a graduate of any curriculum leading to a Master of Science degree in Mechanical or Electrical Engineering who has demonstrated academic excellence through attainment of a high Quality Point Rating in addition to an outstanding thesis, and who has exhibited leadership potential in the engineering area.

CHIEF OF NAVAL OPERATIONS AWARD FOR EXCELLENCE IN OPERATIONS RESEARCH. This award is presented semiannually to an outstanding United States Navy or Marine Corps graduate of the Operations Research/ Systems Analysis curriculum. The award is made on the basis of academic record, performance during the student's experience tour, and faculty recommendations.

ADMIRAL WILLIAM ADGER MOFFETT AWARD. This award is presented annually to an outstanding graduate of the Aeronautical Engineering curriculum. The award is made on the basis of the student's academic excellence, including thesis, and his career potential.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS AWARD. This award is presented semiannually to the graduate in an advanced communications degree program achieving an outstanding academic record and exhibiting those qualities indicative of an outstanding military officer.

CHIEF OF NAVAL OPERATIONS COMMUNICATIONS CERTIFICATE. This certificate is presented quarterly to the Master of Science graduate who shows the greatest academic improvement in a communications curriculum.

CHIEF OF NAVAL OPERATIONS ASW AWARD. This award is given annually to the most outstanding student graduating from the antisubmarine warfare curriculum.

DIRECTOR OF NAVAL INTELLIGENCE GRADUATION AWARD. This award is presented annually to recognize the most outstanding student in the Naval Intelligence curriculum.

NAVAL SEA SYSTEMS COMMAND AWARD IN WEAPONS ENGINEERING EXCELLENCE. This award is given annually to the most outstanding officer graduate of the Weapons Systems Engineering curricula.

NAVAL UNDERWATER SYSTEMS AWARD IN SUBMARINE WARFARE SYSTEMS. This award is given annually to the officer student graduate who has demonstrated the greatest contribution in the field of submarine warfare systems.

CERTIFICATES OF COMPLETION

Certificates of completion are issued to students who complete programs but do not qualify for a degree. To establish eligibility for a Certificate of Completion, a student must normally maintain an overall QPR of 2.0 or better.

REQUIREMENTS FOR THE MASTER OF ARTS AND MASTER OF SCIENCE DEGREES

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:

a. 32 quarter hours of graduate level credits of which at least 12 quarter hours must be earned on campus.
b. A thesis or its equivalent is required. If the thesis be waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.
c. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master's degree requires:

a. A baccalaureate degree or the equivalent.
b. Appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.
c. A demonstrated academic potential for completing the curriculum.

4. In order to qualify for a Master's degree, a student first must be admitted to candidacy for the degree. Application for such admission to candidacy shall be made to the Dean of Academic Administration, via the Chairman of the department of the major, subsequent to completion of 50% of a curriculum and prior to completion of 75% of the curriculum.

a. Students having a Total QPR of 3.00 or greater at the time of application automatically will be admitted to candidacy.
b. Students having a Total QPR from 2.50 to 2.99 inclusive, will require approval by the Academic Council upon recommendation of the Chairman of the department of the major for admission to candidacy.
c. Students having a Total QPR below 2.50 will not be admitted to candidacy for a Master's degree.

5. To be eligible for the Master's degree, the student must attain a minimum average quality point rating of 3.00 in all of the 4000 and 3000 level courses in his curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

REQUIREMENTS OF THE DEGREE: ENGINEER

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.
b. An acceptable thesis.
c. One academic year in residence.
d. Departmental requirements for the degree in a specified Engineering field.
e. A quality point rating of at least 3.00 in all graduate courses in the curriculum and either 2.50 in the remaining courses or 2.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DOCTOR'S DEGREE

Any program leading to the Doctor of Philosophy or Doctor of Engineering shall require the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the School. A requirement for admission is Bachelor's degree that includes the prerequisites for full graduate status in the department of his major study.

A general outline of a candidate's progress through the program is as follows:

a. Application to the appropriate department chairman for admission and acceptance.
b. Appointment of the student's Doctoral Committee, which bears responsibility for the study program and guidance of the research program.
c. Inclusion of one or more minors in the study program; for the Doctor of Philosophy at least one foreign language. For Doctor of Engineering, demonstrated proficiency in computer programming is required, with no foreign language.
d. When study program is essentially complete, administration of the Qualifying Examination, including both oral and written parts.
e. Admission to candidacy and start of work on Doctoral Dissertation on a subject approved by the Doctoral Committee.
f. Upon completion of dissertation and acceptance by Doctoral Committee, administration of final oral examination.
g. Upon unanimous recommendation of Doctoral Committee, Academic Council makes final decision on recommendation for award of the degree.

NAVAL POSTGRADUATE SCHOOL FOUNDATION

The Foundation is a non-profit corporation whose purposes are:

> "to solicit, receive, and administer contributions and make donations and dispense charitable contributions . . . and otherwise aid, encourage and support the traditions of the Naval Postgraduate School . . ."

The corporation was formed in December 1970, and has since served as a vehicle by which large and small tax-exempt gifts have been easily and quickly given to the School. These gifts are all applied to those needs or purposes which would otherwise — in these days of severe fiscal restraint — be poorly- or not-at-all funded.

The Rear Admiral John Jay Schieffelin Award for Excellence in Teaching was endowed through the Foundation. A black granite sculpture, FLIGHT, located in the Dudley Knox Library, was donated to help publicly honor the recipients of this prestigious and valuable award.

The Foundation, in cooperation with the Office of Naval Research, administers the Carl E. Menneken Fellowship for Scientific Research. This annual award of $1,000 has the dual objectives of furthering the progress of engineering and science in areas of importance to the Navy and to provide aid to a worthy doctoral student involved in a research program expected to be of benefit to the Navy. The award honors the memory of Carl E. Menneken who devoted his career to the Navy as Professor of Electronics and Dean of Research Administration at the Postgraduate School.

Dependents graduating from high school while their sponsor is attached to the Naval Postgraduate School are eligible for scholarships offered by the Naval Postgraduate School Foundation. These scholarships are based entirely on merit, and are usually awarded in the amount of $500 per recipient.

The School's Sailing Association owes the majority of its present assets to donations made to the Foundation. Small donations have also been received from some "friends of the Library" who wished to create a small but meaningful and useful memorial.

The Directors of the corporation are civilians, except for the Superintendent who serves to assure that only gifts appropriate to the School are accepted.

Individuals wishing to participate in the work of the Foundation may write to the Secretary, Naval Postgraduate School, Monterey, California 93940.

SUPERINTENDENT'S GUEST LECTURE PROGRAM

Throughout the Academic Year lectures will be presented on Tuesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international, government sociological, and military affairs. Occasionally speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

CIVILIAN EDUCATION PROGRAM

All civilian employees of the United States government are eligible to enroll in the courses, curricula, and degree programs of the School. Enrollment is subject only to the approval of the individual's employing agency for his participation. An individual may enroll in one of the regular curricula designed for officers, in a specially designed degree program, in a selection of courses making up a non-degree program, or in a Continuing Education course.

Regular Curricula. The School's programs for officers are designed to meet the requirements of the services for specific education. Civilian students may enter any curriculum at the point at which they are qualified and complete the curriculum along with regular officer students. The available curricula are described later in the catalogue.

Degree Programs. For a civilian student a program can be designed which leads to the award of a graduate degree and which meets his educational goals. The program can be designed to meet the degree requirements in a minimal time. A preparatory phase (off-campus), designed to minimize the residency requirement, is developed in consultation with a School advisor and may include courses at a local university, self-study courses from the School, and other appropriate activities. The residency phase, usually one year or less in length, entails completing the course work, passing any required qualifying examinations, and starting a thesis project. The third phase (on or off-campus) involves completion of the thesis project.

Degree programs are described in the departmental descriptions. Those available include Masters degrees in the areas of Naval Intelligence, National Security Affairs, Operations Research, Financial Management, Personnel Management, Systems Acquisition Management, Communications Management, Computer Systems Management, Material Management, Human Resources Management, Mathematics, Physics, Meteorology, Oceanography, Aeronautical Engineering, Mechanical Engineering, Electrical Engineering, Systems Technology, Applied Science, Anti-Submarine Warfare, Electronic Warfare, Avionics, and Computer Science.

Engineer degree programs and the Doctor of Engineering degree are available in Aeronautical, Electrical and Mechanical Engineering.

The Doctor of Philosophy is given in Physics, Oceanography, Meteorology, Operations Research, Aeronautical Engineering, Electrical Engineering and Mechanical Engineering.

Non-Degree Programs. Civilian employees may desire to pursue a program for professional advancement without a degree objective. Any of the School's regular courses are available for such efforts. For groups of employees from an agency, special courses can be offered to meet particular requirements, provided the demand is in an area of expertise of the School.

Continuing Education. The opportunities available include short course offerings both on and off campus, as well as self-instructional courses for credit to be taken individually. The Continuing Education program is given in detail in the following section.

There are no formal requirements for enrollment in the Continuing Education Program or for a non-degree program. For admission to a program leading to a graduate degree, the minimum qualification is an accredited baccalaureate degree with appropriate preparation for the proposed degree program. The School will require submission of official transcripts covering all college work completed to date. In some cases, submission of Graduate Record Examination Aptitude test scores may be requested.

The point of contact for information pertaining to on campus programs and admission to degree programs is the Dean of Academic Administration, Code 014, telephone (408) 646-2392 or Autovon 878-2392. For information concerning continuing education, the contact point is the Executive Director of Continuing Education, Code 500, telephone (408) 646-2558 or Autovon 878-2558.

CONTINUING EDUCATION PROGRAM

The Naval Postgraduate School Continuing Education (NPSCE) Program was established in June 1974 as a means of providing extended educational services that will more comprehensively fulfill the school's assigned mission. These extended services include the offerings of self-study credit courses off campus; the delivery, both on and off campus, of professionally relevant short courses; and expanded educational counseling. The self-study credit course offerings and the short course offerings are given in the annual NPSCE catalogues which have wide distribution. CNETINST 1520.8 (29 Aug. 75) is the authenticating instruction for the NPSCE program. This program is administered by the Continuing Education Office.

Selected graduate preparatory courses are delivered off campus in a self-study self-paced mode for the same academic credit as received when taken on campus. These self-study courses are delivered to officers at their current duty stations for completion during off-duty hours or work/study periods. They have been selected primarily from courses normally taken in the initial phase of curricular programs at the Naval Postgraduate School and serve to provide general educational upgrading opportunities. More particularly, their completion will reduce student time required in subsequent fully-funded graduate education programs. The delivery of a self-study credit course normally requires the local participation of a qualified tutor (e.g., a fellow officer with requisite graduate education). Specific information about the Personalized System of Instruction (PSI) used to deliver these courses is in the NPSCE catalogue which may be obtained from the Continuing Education Office, Code 500, Naval Postgraduate School, Monterey, CA 93940, Autovon 878-2558.

Application for enrollment in a self-study course may be made at any time. Applicants may use the appropriate form contained in the last section of the NPSCE catalogue or write a letter using the format specified in CNETINST 1520.8. Applications should be forwarded to Superintendent (Code 500), Naval Postgraduate School, via the command holding the applicant's service or personnel record in accordance with CNETINST 1520.8. Self-study courses are also available to civilian employees of the Federal government.

The Naval Postgraduate School will provide general educational counseling service to assist officers in planning their educational needs on a timely basis consistent with Navy requirements and career fields. Inquiries may be addressed to the Office of Continuing Education.

Commands may apply for the delivery of short courses by completing the appropriate form in the NPSCE catalogue. Courses applied for in this manner will, upon approval, be supported for delivery by the Chief of Naval Education and Training.

Commands with available funds may also arrange for the delivery on site of courses in the NPSCE catalogue or special short courses to meet specific needs on a direct reimbursable basis to the NAVPGSCOL. Delivery costs may be obtained from the Continuing Education Office.

Special short courses are offered yearly at the NAVPGSCOL on a tuition-fee basis. Tuition fees vary between $200 to $400 per course and must be paid by the student's sponsoring activity. These courses are given in response to individual requests. More information on these courses is available from the Continuing Education Office, Naval Postgraduate School, Monterey, California 93940, or telephone (408) 646-2558 or AUTOVON 878-2558.

W. R. CHURCH COMPUTER CENTER

STAFF

DOUGLAS GEORGE WILLIAMS, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

ROGER RENE HILLEARY, Manager, User Services (1962); B.A., Pomona College, 1953; M.S., Naval Postgraduate School, 1970.

EDWARD NORTON WARD, Manager, Systems Programming (1959); B.A., Univ. of California at Los Angeles, 1952.

DAVID FREDRIC NORMAN, Manager, Operations (1969).

MAXWELL JOSEPH FEUERMAN, Manager, Information Services (1961).

LOIS MAY BRUNNER (1961); B.S. Naval Postgraduate School, 1968.

MICHAEL GARY CORCORAN (1969); B.A., Univ. of California at Santa Cruz, 1969.

HANS WELTER DOELMAN (1967); B.S., Univ. of California at Berkeley, 1956.

RICHARD EUGENE DONAT (1968); B.S., California State Polytechnic Univ., 1967.

LLOYD GEORGE NOLAN (1971); B.S., Colorado State Univ., 1968.

BERNADETTE REQUIRO PEAVEY (1967); B.A., Univ. of California at Berkeley, 1963.

SHARON DILL RANEY (1964); B.S., California State Polytechnic Univ., 1964.

KATHRYN BETTY STRUTYNSKI (1967); B.S., Brigham Young Univ., 1953.

ARTURO VALLES (1970); B.S., Trinity Univ., 1957.

** The year of joining the Postgraduate School is indicated in parentheses.*

The Naval Postgraduate School was one of the first educational institutions to use digital computers in its instructional and research programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic departments. In December, 1969, the Facility was renamed the "W. R. Church Computer Center" in memory of Professor Church, Chairman of the Department of Mathematics (1947-66) who recognized very early the value of computers in education and was instrumental in obtaining the first computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in connection with instruction, research, or administrative activities.

These services are based on an IBM 360, Model 67 computer system which was installed in April 1967. The present hardware complement includes two Model 67 processing units; four different levels of storage, including 2 million bytes of core, four million bytes on a drum, 24 disk drives with 29 million bytes each and 4 drives with 100 million bytes each, nine magnetic tape units; two high-speed plotters, forty remote hard-copy and video terminals, and an IBM 2250 Graphical Display Unit. The two processors are identical and can access directly, or control, all components of the system including core storage modules, input/output controllers and devices. The resources of the system can be allocated easily to create different operational environments.

The Center offers users two modes of operational service, viz., batch-processing (under OS/MVT with HASP) and general-purpose, time-sharing (under CP/CMS). Both operating systems offer a great variety of programming languages, libraries of subroutines and other software facilities. Language support includes

FORTRAN IV, WATFOR, Assembler, COBOL, APL, PL/1, BASIC, ALGOLW, GPSS and SIMSCRIPT.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to the computer early in their curricula at the Naval Postgraduate School and encouraged to use it in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered by the Departments of Computer Science, Electrical Engineering, Mathematics, Operations Research and Administrative Sciences.

The Center has a staff of 26 people of whom 11 are mathematician/programmers. The professional staff provides a consulting service in applications programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new hardware and software facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, and numerical analysis.

In 1975 the Center began to provide data processing support to the tenant activity, MARDAC (Manpower Research and Data Analysis Center).

DUDLEY KNOX LIBRARY

STAFF

PAUL SPINKS, Associate Professor and Director of Libraries (1959)*; B.A., Univ. of Oklahoma, 1958; M.S., 1959.

MARY THERESE BRITT, Assistant Professor and Associate Director of Libraries (1966); B.S., College of St. Catherine, 1947.

PASCO DOMENIC COLLELO, Research Reports Librarian (1973); B.S., Brown Univ., 1951; M.A., California State Univ. at San Jose, 1972.

NOEL WILLIAM JOHNSON, Assistant Professor and Head Research Reports Librarian (1970); B.A., Univ. of Nevada, 1949; B.L.S., Univ. of California at Berkeley, 1954.

GEORGIA PLUMMER LYKE, Reference Librarian (1952); A.A., Hartnell College, 1940.

ROGER McQUEEN MARTIN, Reader Services Librarian (1974); B.S., Univ. of Texas, 1949; M.S., Univ. of Texas, 1958.

DIANE SHIRLEY NIXON, Head Acquisitions Librarian (1969); B.A., California State Univ. Fullerton, 1968; M.S., Univ. of Southern California, 1969.

LOUIS OVEN, Cataloging Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., 1968; M.A., Univ. of California at Berkeley, 1968.

CLEO ELIZABETH PETERSON, Research Reports Librarian (1958); A.A., Red Oak College, 1938.

FRANCES EMANUELA MARIA STRACHWITZ, Research Reports Librarian (1970); B.S., Dominican College of San Rafael, 1951; M.A., Univ. of Denver, 1968.

HELEN JEANETTE WALDRON, Head Cataloging Librarian (1975); B.A., Univ. of Washington, 1937; M.A., Univ. of California at Berkeley, 1951.

** The year of joining the Postgraduate School is indicated in parentheses.*

The Dudley Knox Library, a building of 50,000 square feet, was dedicated in 1972. The collections housed therein serve the research and instructional needs of the community, comprising students, faculty and staff of all departments of the Postgraduate School. They embrace an active collection of 163,000 books, bound periodicals and pamphlets; 10,200 book and journal volumes in microform; 166,000 research reports in hard copy and 146,000 in microform; and over 1,700 periodicals and other serial publications currently received. These materials parallel the School's curricular fields of engineering, physical science, managerial sciences, operations research, naval sciences, and national security affairs.

The Reader Services Division provides the open literature sources, such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It provides access to more than 35 computer data bases in the curricular fields of interest by means of DIALOG On-Line Information Retrieval Service (Lockheed Information Systems). It furnishes facilities for microform reading and printing and for reproduction of printed matter. It borrows publications not held in its collections from other libraries.

The Research Reports and Classified Materials Division is the principal re-

pository for research documents received by the School. It houses the Library's classified and unclassified research reports in hard copy and microfiche. A machine information storage and retrieval system that utilizes the School's computer facilities is available for bibliographic searches of research and development documents held by the division. An SDI (Selective Dissemination of Information) Service is also available. In addition, the Division is now able to perform, via its own remote terminal, computer searches of the data banks of the Defense Documentation Center in Alexandria, Virginia, and thus to provide rapid and efficient access to the 800,000 documents held by the Center.

The Christopher Buckley, Jr., Library is located on the second floor of the Library. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who began donating books to the School for this Library in 1949.

CURRICULAR OFFICES

Title	Organizational Code	AUTOVON
Administrative Science	36	878-2536
Aeronautical Engineering	31	878-2491
Antisubmarine Warfare	331	878-2116
Computer Technology	37	878-2174
Electronics and Communications	32	878-2056
Environmental Sciences	35	878-2044
Naval Engineering	34	878-2033
Naval Intelligence/National Security Affairs	38	878-2228
Operations Research/Systems Analysis	30	878-2786
Weapons Engineering	33	878-2116

CURRICULA

Curriculum	Curriculum Number	Normal Length (Months)	Normal Convening Dates	Cognizant Curricular Office Code
Administrative Science				
(Material Movement)	813	12-18	July	36
(Procurement Management)	815	12-18	January, July	36
(USMC, USCG, USA and Allied Officers)	817	12-18	January, July	36
(Systems Inventory Management)	819	12-18	January, July	36
(Material Management)	827	12-18	January, July	36
(Financial Management)	837	12-18	January, July	36
(Manpower/Personnel Management)	847	12-18	January, July	36
(Human Resources Management)	857	12-18	January, July	36
Aeronautical Engineering	610	18-24	Any Quarter	31
Aeronautical Engineering-Avionics	611	18-24	Any Quarter	31
Air-Ocean Science	373	18-24	Any Quarter	35
Antisubmarine Warfare	525	24	March	331
Command, Control and Communications (C^3)	365	18	September	
Communications Engineering	600	18-27	March, September	32
Computer Science	368	18-21	March, September	37
Computer Systems	367	12-15	March, September	37
Electronic Warfare - Engineering	591	18-27	March, September	32
Electronic Warfare Systems Technology	595	18-24	March	32
Engineering Electronics	590	18-27	March, September	32
Engineering Science		6	March, September	
Meteorology	372	18-24	Any Quarter	35

National Security Affairs				
(Middle East, Africa, South Asia)	681	12-24	Any Quarter	38
(Far East, Southeast Asia, Pacific)	682	12-24	Any Quarter	38
(Europe, USSR)	683	12-24	Any Quarter	38
(International Organizations and Negotiations)	684	12-18	Any Quarter	38
(Strategic Planning)	686	12-18	Any Quarter	38
Naval Engineering	570	18-27	Any Quarter	34
Naval Intelligence	825	18	Any Quarter	38
Oceanography	440	18-24	Any Quarter	35
Operations Research/ Systems Analysis	360	18-24	March, September	30
Systems Acquisition Management	816	15-16	March, September	36
Telecommunications Systems	620	15-18	September	32
Underwater Acoustics	535	18-24	September	33
Weapon Systems Science	531	18-24	March (September)	33
Weapon Systems Technology	530	18-24	September (March)	33

ADMINISTRATIVE SCIENCE PROGRAMS CURRICULA NUMBERS 813, 815, 816, 817, 819, 827, 837, 847, 857

JAMES THOMAS FLEMING, Jr., Commander, U.S. Navy; Curricular Officer; B.A., Dartmouth College, 1955; M.B.A., Univ. of Santa Clara, 1972.

JOSEPH DOMINIC MONZA, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.A., Geneva College, 1959; M.S., Management, Naval Postgraduate School, 1970.

ALEXANDER CLAYTON CROSBY, Commander, U.S. Navy, Academic Associate for Procurement (815); B.S., Univ. of California at Berkeley, 1957; MBA Harvard Univ., 1972.

LESLIE DARBYSHIRE, Academic Associate for Financial Management (837); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

CARSON KAN EOYANG, Academic Associate for Human Resources Management (857); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

JAMES KERN HARTMAN, Academic Associate for Administrative Science Programs (817); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

MELVIN BERNARD KLINE, Academic Associate for Systems Acquisition Management (816); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

ALAN WAYNE MCMASTERS, Academic Associate for Systems Inventory Management (819) and Material Management (827); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

ROBERT WILLIAM SAGEHORN, Lieutenant Commander, U.S. Navy; Academic Associate for Material Movement (813); B.S., California Maritime Academy, 1959; B.A., Naval Postgraduate School, 1970; M.S., 1975.

JOHN DAVID SENGER, Academic Associate for Manpower/Personnel Management (847); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

OBJECTIVE — Postgraduate education in the Administrative Science curricula is designed to increase an officer's potential in all assignments throughout his military career, including operational, technical, managerial and policy-making billets. The interdisciplinary approach, which includes the study of the use of quantitative methods in problem solving, behavioral and managerial science, economics, and financial management, provides the officer-student with new ways of coping with problems which will be encountered on subsequent duty assignments.

ADMINISTRATIVE SCIENCE CURRICULA (GROUP MN)

CURRICULUM 813 - Material Movement

CURRICULUM 815 - Procurement Management

CURRICULUM 817
- Allied Officers - Various Management Options
- U.S. Army - Operations Research/ Systems Analysis (Business)
- U.S. Marine Corps - Defense Systems Analysis
- U.S. Coast Guard - Management Science

CURRICULUM 819 - Systems Inventory Management

CURRICULUM 827 - Material Management

CURRICULUM 837 - Financial Management

CURRICULUM 847 - Manpower/ Personnel Management

CURRICULUM 857 - Human Resources Management

OBJECTIVE (SPECIFIC) — to provide graduate level education in the managerial skills essential to the professional development of military officers with diverse academic backgrounds. Upon successful completion of the curriculum, the officer will have a sound understanding of the financial processes of major industries in their dealings with the private and public sector; an appreciation of capital budgeting and management of the dollar resources of the Services; broad knowledge of the inventory and allocation processes and the elements of the procurement cycle, including contract administration; and a deep understanding of individual, group, and organizational behavior. A graduate of this curriculum is thus prepared to understand and make the managerial decisions critical to effective development and utilization of complex military systems.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above average grades is required. Completion of at least two semesters of college mathematics at or above the level of college algebra or trigonometry is considered to be the minimum mathematical preparation. Officers who wish to enhance their opportunity for selection to any of the Administration Science programs are strongly encouraged to take courses in the Fundamentals Program Area through off duty education or through the Naval Postgraduate School Office of Continuing Education.

DESCRIPTION — The curricula noted above are interdisciplinary programs which integrate mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty concentration area into an understanding of the process by which the defense mission is accomplished. Subspecialty concentration areas are specified by ordering officers into a specific curriculum number — 813, 815, 819, 827, 837, 847 or 857 for U.S. Navy officers. USMC and USCG officers are ordered into 817 for Defense Systems Analysis of Management Science, respectively, or to one of the other numbered curricula. U.S. Army students are currently ordered into curriculum 817 for a tailored Operations Research/Systems Analysis Business program. Allied officers are ordered into 817 or one of the other numbered curricula dependent upon the desires of their sponsoring service. Officers successfully completing the program will be awarded the degree of Master of Science in Management. In addition, Naval officers who complete one of the approved programs are awarded a subspecialty billet code (P-code) appropriate to their concentration area. Matriculation for all programs occurs semiannually in January and July, except for Material Movement which convenes only in July. Matriculation at times other than January and July may be coordinated between Curricular Officer and Pers 440 on a case basis.

The curricula share a common core of fundamental and graduate courses, with specialization occurring as the result of required and elective graduate courses and thesis research in the concentration area. The Fundamentals Program is designed to bring all students up to a common level before entry into graduate study. This portion of the program varies in length from zero to two quarters, depending upon the student's background, prior academic work, and time away from academic endeavors. The Graduate Program requires four quarters to complete.

Classroom instruction is supplemented by the weekly guest lecturer seminar, MN 0001, which affords the student an opportunity to participate in the discussions of pertinent topics with senior military officers, business executives, and prominent educators.

Officers from the U.S. Services as well as allied officers start the curriculum with widely varied academic backgrounds and complete intellectually demanding courses in many disciplines. Upon entry into the program, each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Student's curriculum will be transferred. In addition, validation or credit by examination

is encouraged where knowledge of the material has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the Fundamentals material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

Fundamental Program

This portion of the program provides the necessary background and intellectual tools for successful study in a graduate program in management. The courses contained in the Fundamentals Program are considered prerequisites to the four quarters of graduate work. Credit transfer and course validation is especially applicable to this area. It is Navy policy to educate officers to the minimum level essential for satisfactory performance in validated billets. In an era of increased manpower costs and reduced budgets, it is obvious that education costs can be reduced and billet requirements can be satisfied most economically by selecting those officers for postgraduate education who can complete program requirements in the minimum time. Officers can enhance their selectability for Administrative Science Curricula by completing as many of the prerequisite courses, or their equivalents, listed in the Fundamentals area, through off duty education or through the NPS Office of Continuing Education.

The model curriculum includes the following comprehensive fields:

Mathematics: provides the quantitative tools required for successful pursuit of the remaining courses.

MA 2300	Mathematics for Management	5-0
PS 3005	Probability	3-0

Note: U.S. Army 817 students follow a different Mathematics program.

Economics: provides an introduction to economic theory and decision processes.

MN 2031	Economic Decision Making	4-0
MN 3140	Microeconomic Theory	4-0

Accounting: provides the necessary background in basic accounting principles, costing, and budgeting.

MN 2150	Financial Accounting	4-0
MN 3161	Managerial Accounting	4-0

Organization/Behavior: provides an introduction to personal/group behavior and the relationship to organizational management.

MN 2106	Individual and Group Behavior	4-0
MN 3105	Organization and Management	4-0

Data Processing: provides an introduction to data processing equipment and provides the student with programming skills for use in follow on courses.

CS 2010	Introduction to Computers	2-0
CS 2103	Cobol Programming	1-2

Graduate Program (813, 815, 817, 819, 827, 837, 847, 857)

The graduate portion of the curricula consists of a common core of required courses, elective and, in some cases, required courses in the subspecialization concentration area, at least one free elective, and thesis research. Any transfer of graduate credit which may be applicable can be used to reduce the number of courses in this area.

Required Courses:

MN 3101	Personnel Management and Labor Relations (*Note 1*)	4-0
MN 3172	Public Policy Processes (*Note 2*)	4-0
MN 3183	Management Information Systems	4-0
PS 3211	Statistics (*Note 3*)	4-0
OS 3212	Operations Research for Management	4-0
MN 3812	Communications in Organizations (Note 4)	2-0 to 4.0
MN 4105	Management Policy	4-0
MN 4145	Systems Analysis	4-0

Note 1: Not required for USMC and U.S. Army students.
Note 2: Not required for Allied students.
Note 3: Not required for U.S. Army students.
Note 4: Required of all USN officers.

Material Movement (813)

Required Courses - Graduate Program

MN 3372	Material Logistics	4-0
MN 3373	Transportation Management	4-0
MN 4373	Transportation Policy	4-0

Electives

MN 4152	Decision Making for Financial Management (*Note*)	4-0
MN 3371	Procurement and Contract Administration	4-0
MN 3374	Production Management	4-0
MN 3376	Selected Topics in Logistics	2-0 to 5-0

Note - required of all USN Supply Corps Officers

Procurement Management (815)

Required Courses - Graduate Program

SM 3304	Procurement Planning and Contract Negotiation	4-0
SM 3305	Contract Administration	4-0
MN 4371	Procurement Policy	4-0
AS 3501	Project Management	4-0

Electives

MN 4152	Decision Making for Financial Management (*Note*)	4-0
OA 4614	Cost Estimation	4-0
SM 4302	Public Expenditure, Policy & Analysis	4-0
MN 3372	Material Logistics	4-0

Note: Required of all USN Supply Corps Officers

Defense Systems Analysis (817-USMC)

Required Courses - Graduate Program

MN 3371	Procurement and Contract Administration	4-0
	or	
SM 3304	Procurement Planning and Contract Negotiation	4-0
MN 4154	Financial Management in the Navy	4-0
OA 4614	Cost Estimation	4-0

Electives

Two from List A, one from List B and one Free Elective. Substitutes with permission of Marine Corps Representative and the Curricular Officer

List A

SM 4304	Seminar in Systems Acquisition	4-0
MN 3124	Analysis of Bureaucracy	4-0
MN 4151	Internal Control and Auditing	4-0
MN 4152	Decision Making for Financial Management	4-0
MN 4162	Cost Accounting	4-0
MN 4181	Applications of Management Information Systems	4-0

List B

MN 3760	Manpower Economics	4-0
MN 4191	Decision Analysis	4-0
MN 4920	Public Expenditure Analysis	4-0
MN 4941	Microeconomic Theory and Policy	4-0
AS 4613	Theory of Systems Analysis	4-0

Management Science (817-USCG)

Electives (choice of 6)

OS 3214	Operations Research Methodology	4-0
MN 3215	Selected Topics in Management Science	2-0 to 5-0
MN 3645	Investigative Methods of Economics I	4-0
MN 4181	Application of Management Information Systems	4-0
MN 4192	Workshop in Management Science	2-0 to 5-0
MN 4193	Selected Topics in Management Science	2-0 to 5-0
OA 3604	Linear Programming	4-0
OA 3620	Inventory I	4-0
OA 4634	Games of Strategy	4-0
MN 4191	Decision Analysis	4-0
OA 4651	Search Theory and Detection	4-0

Operations Research/Systems Analysis Business (817-USA)

Required Courses - Fundamentals

MA 2045	Computational Matrix Albegra	3-0
MA 1100	Calculus and Vector Analysis	5-2

Required Courses - Graduate Program

OA 3604	Linear Programming	4-0
OA 4656	Operations Research of Army Weapons Systems	4-0
PS 3011	Probability and Statistics for Management I	5-0
PS 3012	Probability and Statistics for Management II	4-0
MN 4181	Applications of Management Information Systems	4-0

Electives (choice of 3)

OA 3704	Stochastic Models I	4-0
OA 4654	Combat Models	4-0
MN 3645	Investigative Methods of Economics I	4-0
OA 4614	Cost Estimation	4-0
OA 4631	Nonlinear and Dynamic Programming	4-0
OA 4633	Networks Flows and Graphs	4-0
OA 3620	Inventory I	4-0
OS 3214	Operations Research Methodology	4-0
OA 3657	Human Factors in Systems Design I	4-0
PS 4510	Selected Topics in Probability and Statistics	2-0 to 5-0
MN 4191	Decision Analysis	4-0

Systems Inventory Management (819)

Required Courses - Graduate Program

MN 3372	Material Logistics	4-0
OA 3620	Inventory I	4-0
OA 4622	Seminar in Supply Systems	4-0

Electives

MN 4152	Decision Making for Financial Management (*Note*)	4-0
OA 4621	Inventory II	4-0
MN 3371	Procurement and Contract Administration	4-0
MN 3374	Production Management	4-0
AS 3501	Project Management	4-0
MN 3373	Transportation Management	4-0

Note: Required of all USN Supply Corps Officers

Material Management (827)

Required Courses - Graduate Program

MN 3372	Material Logistics	4-0
MN 3374	Production Management	4-0
MN 3371	Procurement and Contract Administration	4-0

Elective Courses (Supply Corps)

MN 4152	Decision Making for Financial Management (*Note*)	4-0
OA 3620	Inventory,I	4-0
MN 3373	Transportation Management	4-0
AS 3501	Project Management	4-0

Note: Required of all USN Supply Corps Officers

Electives (Aviation Officers)

OS 3306	Systems Effectiveness Concepts and Methods	4-0
OS 4322	Quality Assurance	4-0
AS 3501	Project Management	4-0

Financial Management (837)

Required Courses - Graduate Program

MN 4154	Financial Management in the Navy	4-0
MN 4161	Financial Control Systems	4-0

Electives

MN 3165	Selected Topics in Accounting and Financial Management	2-0 to 5-0
MN 3251	Accounting Theory and Standards	4-0
MN 4151	Internal Control and Auditing	4-0
MN 4152	Decision Making for Financial Management (*Note*)	4-0
MN 4153	Seminar in Accounting and Control	4-0

MN 4162	Cost Accounting	4-0
MN 4165	Selected Topics in Accounting and Financial Management	4-0
MN 4181	Application for Management Information Systems	4-0

Note: Required of all USN Supply Corps Officers

Manpower/Personnel Management (847)

Required Courses - Graduate Program

MN 3111	Personnel Management Processes	4-0
MN 3001	Behavioral Research Methodology	4-0
MN 3124	Analysis of Bureaucracy	4-0
OA 4401	Manpower and Personnel Models	4-0

Electives

MN 4112	Personnel Selection and Classification	4-0
MN 3760	Manpower Economics	4-0
MN 4115	Personnel Motivation	4-0
MN 4114	Personnel Performance Evaluation	4-0
MN 4147	Industrial Relations	4-0
MN 3120	Planning and Control	4-0
OA 4403	Industrial Engineering Requirements Determination	4-0

Human Resources Management (857)

Required Courses - Graduate Program

MN 3114	Organizational Development I	3-0
MN 3115	Human Resource Development	0-4
MN 3001	Behavioral Research Methodology	4-0
MN 4121	Organizational Theory	4-0
MN 3124	Analysis of Bureaucracy	4-0
MN 3002	HRM Data Assessment	0-2
MN 4123	Organization Development II	3-0
MN 4116	Education and Training	4-0
MN 3116	HRM Field Work	0-4
MN 3117	Workshop Design	0-4

Electives

MN 3121	Leadership and Group Behavior	4-0
MN 3122	Comparative Cultures	4-0
MN 3111	Personnel Management Processes	4-0
MN 4147	Industrial Relations	4-0

Thesis Research (813, 815, 817, 819, 827, 837, 847, 857): A total of twelve quarter hours are allocated over the last two quarters for thesis research. The thesis provides the student with the opportunity to apply graduate education and experience to a challenging problem of interest to his service. Thesis topics must receive the approval of a faculty member who acts as the thesis advisor, the Academic Department Chairman and the Curricular Officer.

SYSTEMS ACQUISITION MANAGEMENT CURRICULUM
CURRICULUM NUMBER 816
(GROUP SM)

OBJECTIVE (SPECIFIC) — to provide graduate level education in the fundamental concepts, methodology, and analytical techniques required for the life cycle management of the planning and acquisition of defense systems. This curriculum is designed to meet the military's expanding needs for acquisition management personnel at headquarters and related activities having system acquisition management responsibilities.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above-average grades is required. Completion of differential and integral calculus is considered minimal mathematical preparation. Undergraduate majors in engineering or physical science are highly desirable, though other majors may be acceptable if the officer's experience demonstrates acquired technical competence.

DESCRIPTION — The curriculum consists of basic core courses which provide the fundamental disciplines essential to the acquisition process. Advanced courses are concerned with the structure of acquisition management in the Department of Defense and the decisions required of the acquisition manager. An appreciation of the forces at work in industry and within the executive and legislative branches of government and how these forces impact on systems acquisition policies and procedures is presented throughout the program.

Elective courses are available to enable the student to gain additional knowledge in acquisition areas of particular interest. Classroom instruction stresses theoretical concepts as well as real world problems solving through lectures, case studies, problem exercises and computer simulation exercises. Field trips to industrial and military activities are also utilized to reinforce and further develop classroom concepts.

This curriculum is available to officers from the U. S. military services and allied officers on an individual case basis. Upon successful completion, graduates are awarded the Master of Science in Management, and U.S. Naval officers are also awarded the appropriate subspecialty billet code. Marticulation occurs semiannually in September and March. Entry at other times may be coordinated between Pers 440 and the curricular officer on a case basis. A student's program may not exceed six quarters in length.

Classroom instruction is supplemented by the weekly guest lecturer seminar, SM 0001, which affords the student an opportunity to participate in discussions with senior military officers, industry executives, and officials from governmental agencies.

Upon entry into the program each student's prior academic work and related military experience is evaluated by the Curricular Office. As a result of this evaluation, academic credits for courses previously completed and applicable to the Systems Acquisition Management curriculum will be transferred. In addition, validation or credit by examination is encouraged where knowledge of the materials has been acquired by experience or service courses. Through these procedures, it is expected that, in many cases, the background or preparatory material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

The model curriculum includes the following discipline fields:

Quantitative Methods: provides the tools necessary for successful pursuit of the remaining courses.

OS 3201	Fundamentals of Operations Analysis/Systems Analysis I	4-0
OS 3202	Fundamentals of Operations Analysis/Systems Analysis II	4-0
OS 3203	Survey of Operations Analysis/ Systems Analysis	4-0
SM 3306	Systems Effectiveness Concepts and Methods	4-0
MN 4145	Systems Analysis	4-0

Financial Management and Resource Allocation: provides an understanding of government and corporate finance.

MN 2150	Financial Accounting	4-0
MN 3161	Managerial Accounting	4-0
MN 3143	Managerial Economics	4-0
SM 4302	Public Expenditure Policy & Analysis	4-0

Life Cycle Management: from program conception through acquisition to replacement.

SM 3301	Introduction to Systems Acquisition	4-0
SM 3302	Fundamentals of Project Management	4-0
SM 3304	Procurement Planning and Contract Negotiation	4-0
SM 3305	Contract Administration	4-0
MN 3374	Production Management	4-0
SM 4305	Systems Engineering Management I	4-0
SM 4306	Systems Engineering Management II	4-0

Personnel: introduction to the basic principles of effective personnel management in government and industry.

MN 2106	Individual and Group Behavior	4-0
SM 3302	Fundamentals of Project Management	4-0
MN 3812	Communications in Organizations	2-0 to 4-0

Electives: provides an opportunity to pursue an area in depth. Selection of electives is done in cooperation with the approval of the Curricular Office. At least one of the available electives must be from the Financial Management area. A list of suggested electives follows:

MN 4151	Internal Control and Auditing	4-0
MN 4152	Decision Making for Financial Management	4-0
MN 4154	Financial Management in the Navy	4-0
MN 4161	Financial Control Systems	4-0
MN 4162	Cost Accounting	4-0

MN 4181	Application of Management Information Systems	4-0
MN 4147	Industrial Relations	4-0
MN 3120	Planning and Control	4-0
MN 4123	Organization Development II	3-0
MN 4371	Procurement Policy	4-0
OA 3657	Human Factors in Systems Design I	4-0
MN 4191	Decision Analysis	4-0
MN 3124	Analysis of Bureaucracy	4-0
MN 4942	Structure, Conduct and Performance of the Defense Industries	4-0
SM 4304	Seminar in Systems Acquisition	4-0
OA 4322	Quality Assurance	4-0
OS 4703	Reliability, Maintainability and Safety of Weapons Systems	4-0

Thesis Research: Twelve quarter hours are allocated for thesis research. Emphasis is on military applications in the acquisition field. Topics are chosen with the approval of the Thesis Advisor, the Academic Associate, the Department Chairman and the Curricular Officer.

AERONAUTICAL ENGINEERING PROGRAMS CURRICULA NUMBERS 610 AND 611

LEO ALLEN LUKENAS, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1958; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1965; M.S. in Aeronautical Engineering, Princeton Univ., 1967; M.S. in Management, Naval Postgraduate School, 1974.

ROBERT DIEFENDORF ZUCKER, Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

OBJECTIVE — To provide advanced knowledge and accelerated professional development for aviation officers as a cornerstone in their career dealing with continuing challenges in all aspects of the life cycle of naval aircraft and weapons systems. This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments and policy-making positions.

QUALIFICATIONS FOR ADMISSION — Naval aviation officers are selected for Aeronautical Engineering Programs on the basis of their professional performance and potential for advanced graduate level studies. Normally, students receive orders to the curriculum after completion of their first operational tour and, therefore, have been away from college approximately five years. Since naval aviation officers have many different academic backgrounds, there are several ways to prepare for graduate level studies in Aeronautics.

DIRECT INPUT — The entrance requirement is a baccalaureate in engineering earned with above-average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering, but who have had adequate coverage in the basic physical and mathematical sciences.

INDIRECT INPUT — Officers with a baccalaureate who do not meet the requirements for direct input receive orders to the Engineering Science Curriculum for one or more quarters to prepare for the Aeronautical Engineering Program. Many high performing naval officers with relatively poor undergraduate academic records show evidence of undeveloped academic potential. These officers can qualify for graduate programs following preparation in Engineering Science.

DESCRIPTION — Over the years Aeronautical Engineering Programs have served the Navy and aviation officers by providing graduate level interdisciplinary programs leading to Aero subspecialty codes and several different level academic goals.

Officers enter with varied academic backgrounds and complete intellectually demanding courses in a wide variety of subjects. In addition, the programs include completion of an aviation-oriented thesis project under the personal guidance of a faculty advisor, award of appropriate graduate degrees, and, for some, a practical work experience tour at a Navy or civilian aviation industrial activity. As a result, naval officers develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievements throughout their naval careers. The curriculum is tuned to Navy needs and, as a lesser included part, also satisfies degree requirements established by appropriate academic departments. Degrees presently include MSAE, MSAE and MS Management, Ae.E., D.E., and Ph.D.

Included in the preparatory program is the study of aeronautics aimed at increasing professional knowledge in the officer's warfare specialty of Naval Aviation and academic preparation for rigorous graduate work.

Aeronautical Engineering Programs are multi-disciplinary and provide the opportunity for aviation warfare specialists to study in most areas using general engineering and scientific principles as a cornerstone.

Unrestricted line officers who successfully complete any of the approved programs are awarded an aeronautical subspecialty billet code and subsequently may qualify for the promotion-enhancing designation of "Proven Subspecialist" in accordance with the Operational Technical Managerial System (OTMS). Officers desiring to specialize in a technical management career become prime candidates for Aeronautical Engineering Duty in the Restricted Line. Restricted line officers receive the same subspecialty billet code as URL officers, but specialize in technical management assignments.

The URL officer primarily seeks this professional development to enhance his opportunity for the major career goal of Aviation Command and may use his education and subspecialty to qualify for the additional career goal of Major Project Manager for naval aviation weapon systems. Officers transferring to the Restricted Line (AED) usually seek career goals of Major Project Manager and Command of Naval Air Rework Facilities, Naval Plant Representative Offices, Naval Laboratories, and RDT&E Centers.

Numerous well-defined, specialized aviation billets in all ranks are available for top quality officers throughout the Naval Material Command and associated field activities. This sound billet community provides a viable career progression and, historically, is one reason why Aero graduates continue to form successful career patterns.

Preparatory Phase

Preparation for graduate study is tailored to each officer's background and is programmed for a minimum time consistent with his capability. Each student's academic transcript will be evaluated for possible validation of courses in areas where a sufficiently strong record of achievement is evident. Validation or credit by examination is also possible.

Most subject matter in the preparatory program is available for off-campus study through the Continuing Education Office. All Aero material is structured in "mini-courses" of one credit hour each to encourage rapid completion. Each officer is urged to complete as much of this material as possible before arriving on campus.

Individualized instruction in the preparatory courses enables officers to enter the program at any time. The following courses represent the minimum coverage required for entry into the graduate phase:

Mathematics Sequence

MA 2400	Introduction to Vectors, Matrices, and Vector Calculus	3-0
MA 2401	Introduction to Differential Equations and Complex Functions	4-1
CS 2700	FORTRAN Programming	2-2

Solids Sequence

AE 2001	Particle Dynamics	1-0
AE 2002	Equations of Motion, Systems of Particles	1-0
AE 2003	Rigid Bodies	1-0
AE 2004	Space Kinematics and Vibrating Systems	1-0
AE 2101	Statics and Structural Fundamentals	1-0
AE 2102	Stress and Strain I	1-0
AE 2103	Stress and Strain II	1-0
AE 2104	Bending and Shear in Beams	1-0
AE 2105	Torsion and Buckling	1-0
AE 2106	Energy Theorems in Structural Analysis	1-0

Fluids Sequence

AE 2401	Basic Thermodynamics I	1-0
AE 2402	Basic Thermodynamics II	1-0
AE 2403	Basic Fluid Flow	1-0
AE 2404	Introduction to Viscous Flow	1-0
AE 2405	Varying-Area Flow	1-0
AE 2406	Shocks and Prandtl-Meyer Flow	1-0

Flight Dynamics Sequence

AE 2301	Aerodynamic Fundamentals	1-0

AE 2302	Incompressible Flow	1-0
AE 2303	Thin Airfoils in Plane Flow	1-0
AE 2304	Basic Aerodynamics of Wings	1-0
AE 2305	Aircraft Performance I	1-0
AE 2306	Aircraft Performance II	1-0
AE 2307	Principles of Static Stability and Control	1-0
AE 2308	Dynamic Stability - The Classical Modes	1-0

Electrical/Electronic Sequence (Curriculum 611 only)

EE 2121	Circuit Fundamentals	4-2
EE 2122	Linear Systems Fundamentals	4-2
EE 2211	Electronics Engineering Fundamentals I	4-2
EE 2212	Electronics Engineering Fundamentals II	4-3

Laboratory Sequence

AE 2811	Aeronautical Laboratories I	0-2
AE 2812	Aeronautical Laboratories II	0-2
AE 2813	Aeronautical Laboratories III	0-2
AE 2814	Aeronautical Laboratories IV	0-2

Graduate Phase

Aeronautical Engineering students accepted into a graduate program complete five quarters of graduate work that includes Departmental requirements for the degree of Master of Science in Aeronautical Engineering. Officers demonstrating particularly strong academic performance in the preparatory program may enter a two-year graduate program leading to both the Master of Science in Aeronautical Engineering and the advanced degree of Aeronautical Engineer. Also, a few officers with strong academic performance may complete the Dual Masters Program. In this program the student completes requirements for the Master of Science in Aeronautical Engineering and the Master of Science in Management. Dual Masters graduates are prime candidates for WSAM coding in accordance with BUPERS INT 1040.2 series and receive dual subspecialty qualification codes. An exceptionally well qualified officer may be selected for the Doctoral program.

Students who do not enter a graduate program complete a one-year program including the technical preparatory courses, professional development courses, and studies leading to qualification as an Aviation Safety Officer.

Thesis Research

All graduate students complete an aviation oriented thesis as one of the most important parts of their advanced program.

Professional Development Courses

In addition to the technical courses that form the structure of the graduate program and meet degree requirements, each student takes courses which are particularly relevant to Navy needs and career development. These range from eight to twelve in number and may be selected in various combinations of single courses or sequences from areas such as the following:

Avionics	Aviation Safety
Computer Science	Operations Analysis
Material Science	Financial Management
Systems Reliability	Systems Acquisition Management

Experience Tours

All Engineer degree programs include a six-week practical engineering work experience at a Navy or civilian aviation industrial activity. Normally, these tours are taken after about one year of graduate course work and are oriented in the general field of the student's research project.

AERONAUTICAL ENGINEERING CURRICULUM NUMBER 610

Graduate Study

After the preparatory program, students confirm their selection of specialty area in the Aeronautical Engineering Curriculum. At this point, students also select a thesis topic and prepare their graduate level program of study in consultation with their thesis advisor and the Academic Associate. Sufficient courses are available for in-depth coverage in the following areas:

FLIGHT DYNAMICS includes coverage of the stability and control parameters of a flight vehicle in both pilot-controlled and automatic-controlled modes. Both manned and unmanned vehicles are investigated. Topics include automatic landing systems, missile control, and optimal design.

In *GASDYNAMICS,* operation of flight vehicles in the broad spectrum ranging from hovering flight to hypersonic reentry is investigated, with particular emphasis being placed on the behavior of the gas (air or near-space) in which the vehicle is operating. Subsonic, transonic, supersonic, hypersonic, and plasma flows are covered in detail.

FLIGHT PROPULSION develops fundamentals of fluid dynamics, thermodynamics, and turbomachinery to provide a generalized flight propulsion background. Emphasis on thesis work is directed toward turbomachinery or solid propellants.

For *FLIGHT STRUCTURES,* a study in depth of the mechanics of solids is followed by investigations of the behavior of structural components under conditions of static and dynamic (including aero-elastic) loads (both steady and non-steady). Free, forced, and self-excited vibrations; flutter, gusts, buffet, and stall effects; and wing divergence and control reversal are typical of the topical coverage.

The *AERO COMPUTER SCIENCE* specialty provides knowledge in depth in computer-flight vehicle interface in operation of modern air weapons systems. Computer technology, capability, and applications to the flight vehicle and its mission are stressed.

An *AERO SPACE PHYSICS* specialty includes the study of electro-optics, electromagnetics, quantum mechanics, and space and near-space physics. This specialty sequence prepares the graduate to participate in any of several areas in Navy programs involving missile and space technology.

AERONAUTICAL ENGINEERING-AVIONICS CURRICULUM NUMBER 611

Graduate Study

After the preparatory program students select a thesis topic and prepare their graduate level program of study in consultation with their thesis advisor and academic associate. The graduate program includes a meld of aeronautical and electrical engineering courses. Students select appropriate Aeronautical Engineering courses which complement study in the following avionics areas:

The *ELECTRONIC WARFARE* sequence includes a comprehensive coverage of electronic warfare techniques and systems. Based on an understanding of pulse and CW radar, microwave principles and devices, communication principles and signal analysis methods, the basic jamming, electronic support and countermeasures techniques are studied in the context of current knowledge regarding systems that may be used against us.

The *COMPUTER SYSTEMS ENGINEERING* sequence involves coverage of modern computer systems as applied to flight vehicles. Included are basic computer principles, digital machines, logic elements and design, machine organization and design, man-computer interfaces and interactions and engineering applications of computers. Particular emphasis is placed on micro-processors.

The *FLIGHT VEHICLE CONTROL* sequence includes a comprehensive coverage of control principles underlying the operation of flight vehicles. Included subjects are linear feedback control systems, optimal control methods and the application of statistical and probabilistic methods for optimal control.

ANTISUBMARINE WARFARE PROGRAM CURRICULUM NUMBER 525

ROBERT CECIL WILLEMS, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., Fort Hays Kansas State College, 1965; M.S., Naval Postgraduate School, 1972.

JOHN NORVELL DYER, Academic Associate; B.A. Univ. of California at Berkeley, 1956; Ph.D., 1960.

OBJECTIVES — This program is designed to:

— Educate the officer in the fundamentals of engineering, environmental, and analytical principles so that he will clearly understand the basic phenomena which affect the capability of the ASW system(s) for which he is directly responsible.

— Develop the officer's ability to analyze experiences critically and to state clearly the nature of problems which are associated with ASW systems and operations.

— Educate the officer in the politico-military and decision making environment involving Soviet naval activities, net threat assessment and the Washington decision process.

— Educate the officer in the fundamentals of "systems engineering" so that he will be able to translate operational specifications into systems parameters, to measure systems effectiveness and to view various components of large systems in proper perspective.

— Provide the officer with project-type, practice-oriented experience so that he will develop his ability to relate fundamental concepts directly to ASW operational application.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree of equivalent with mathematics through differential calculus is required. An additional qualification is required in that selectees will have demonstrated outstanding performance and have served in at least one ASW related billet.

DESCRIPTION — The employment of systems in antisubmarine warfare involves complex man-machine interactions; it includes sonar, radar, weapon, communication and information systems and platforms. Therefore, this program is centered around a study of those systems used, and includes extensive breadth in appropriate scientific and technical disciplines. As a culmination of the program, about half of the time in the last six months is devoted to an ASW-related group project or thesis. This provides an opportunity to apply the graduate education and experience to a challenging project which interfaces with current needs in the ASW community.

This interdisciplinary, technical program integrates mathematics, physics, acoustics, electrical engineering, oceanography, operations analysis, human factors, computer science and meteorology. Several short projects are incorporated to further integrate the material presented in lectures and specialized laboratory exercises and to give practice in the systems approach.

The academic content divides naturally into four major categories. One of these is the TECHNICAL area, which includes the analytical and engineering principles upon which ASW systems depend. A second area is the ENVIRONMENT — the ocean and the atmosphere strongly influence the operation, performance and effectiveness of ASW systems. Still another area is OPERATIONAL USE of systems — in this category are, for example, decision theory and performance evaluation. Finally, HUMAN CHARACTERISTICS define an area with marked effect on ASW system performance.

Graduates of the ASW program receive the subspecialty designation XX44 and return to key operationally-oriented ASW billets ashore and afloat. As their careers progress with the Operational-Technical-Managerial System (OTMS) concept they are prepared to perform in all three areas, particularly Operations, and will

typically qualify for the Additional Qualification Designator (AQD) of ASW expert. Graduates are awarded the degree Master of Science in Systems Technology.

Introductory Study

This portion of the program is generally preparatory in nature and some portions of it may be validated by the officer with appropriate operational and academic experience. Because of the integrated nature of the course work in this curriculum, however, validation will be certified only after careful consideration and consultation with the Curricular Officer and Academic Associate.

Undergraduate courses are chosen to prepare students for graduate level work and are selected from the following areas:

- Elements of linear algebra, ordinary differential equations, and fourier series
- Vector calculus
- Partial differential equations and transforms for wave propagation
- Applied probability theory
- Descriptive statistics and operations research models
- Calculation and programming
- Computer systems
- Electronic systems
- Survey of oceanography
- Threat analysis
- Physics of sound in the ocean
- Meteorology for ASW

Graduate Study

This portion consists of integrated course offerings in the several disciplines related to ASW. Typical graduate level topics are listed below:

- Study project on ASW systems performance
- Electromagnetic wave propagation
- Nonacoustic sensor systems
- The defense decision process and ASW Warfare
- Computation and computer simulation
- Fundamentals of acoustics
- Underwater acoustics
- Environmental factors in underwater acoustics
- Environmental prediction for underwater sound propagation
- Signals and noise
- Signal processing systems
- Search, detection and localization models
- Combat models and weapons effectiveness
- Decision analysis and data analysis
- Human vigilance performance
- Systems psychology
- Intelligence

In addition to an ASW-related individual thesis or a group project as the culmination of the program, each officer selects a three-course elective sequence in a specialty area. Examples of such areas are Operations Analysis, Underwater Acoustics, ASW Signal Processing, Human Factors, and Nonacoustic Sensors. Throughout the program seminars provide for guest speakers, discussions of ASW matters, and other special activities.

This program convenes annually in March.

COMMAND, CONTROL AND COMMUNICATIONS (C^3) CURRICULUM
CURRICULUM NUMBER 365

OBJECTIVE: To develop professional expertise and judgment in the area of systems integration and to emphasize the operational aspects of joint command, control and communication (C^3) systems. Graduating officers will

have an understanding of the overall role of C^3 in the pursuit of national objectives,

possess an adequate background knowledge in the exploitation of basic technology, human capabilities and joint military operations in current C^3 systems,

and can

perform plans and requirements studies in support of acquiring new C^3 systems, and

contribute to crisis management.

This program provides an officer the educational strength to enhance abilities and performance leading to an efficient, effective and rewarding military career.

DESCRIPTION: The Command, Control and Communications (C^3) curriculum is in the development stage at the time of printing of this catalog. Planning is for the initial student input in September 1977 with an annual influx of approximately 30 students. Participating students are projected to be at 04-05 levels, and may include highly qualified senior 03s, with the Air Force, Navy and Army participating equally. The C^3 curriculum is interdisciplinary in nature composed of course work from the areas of computer science, operations research, administrative science, electrical engineering, and national security affairs. Graduates of this program are expected to be assigned to joint duty in C^3 consistent with the needs of the parent Service. A major goal of the curriculum is to provide a formal academic program which will provide the student some capabilities to operate effectively in such diverse areas as military decision making, current and future C^3 systems design, crisis management, the World Wide Military Command Control System (WWMCCS), joint military operations, war games and data base management.

The command, control and communications (C^3) curriculum is considered a nominal program structured to the requirements of selected officers who have outstanding operational performance records. Individual programs of study can be formatted to an individual officer's educational background and validation of courses is highly encouraged. Advanced courses are available in Electronic Warfare Systems, Communications Satellite Systems Engineering, Software Systems Development, Real-time Combat Direction Systems, Campaign Analysis, Defense Resources Allocation, Systems Acquisition Management, etc., for qualified students.

Integral to the program will be a schedule of C^3 related seminar speakers, temporary duty at the Department of Defense Computer Institute (DODCI) for WWMCCS architecture presentations, and orientation excursions to various C^3 facilities such as CINCPAC headquarters, Camp Smith, Hawaii, Strategic Air Command (SAC) headquarters, Offutt AFB, Nebraska, and the National Military Command Center (NMCC) Washington, D.C. area. A thesis requirement provides the student an opportunity to select a scientific topic for investigation and apply newly acquired knowledge.

COMPUTER TECHNOLOGY PROGRAMS CURRICULA NUMBERS 367 AND 368

WINDOM LAWRENCE ESTES, Commander, U.S. Navy; Curricular Officer; B.S. with major in Mathematics, Naval Postgraduate School, 1963, M.S. in Computer Science, 1970.

NORMAN FLOYD SCHNEIDEWIND, Academic Associate for Computer Systems; B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (Engr), 1970; D.B.A., 1966.

VICTOR MICHAEL POWERS, Academic Associate for Computer Science; B.S., Univ. of Michigan, 1963; M.S.E.E., 1964; Ph.D., 1970.

THOMAS JOSEPH BATZEL, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1963; M.S. in Computer Systems Management, Naval Postgraduate School, 1969.

COMPUTER SYSTEMS CURRICULUM CURRICULUM NUMBER 367 (GROUP PL)

OBJECTIVE — To provide a graduate with the knowledge, skills, and practical understanding necessary to evaluate the changes and advances in the management of computers in the Military Services. In addition, the graduate possesses the understanding necessary for the critical management decisions needed in the development and utilization of complex computer-based military systems. The program is designed to meet the needs of the Military Services for a technically qualified officer with the managerial skills essential to the successful implementation and effective utilization of computer based systems in military operations. Application of classroom theory to the management of current computers and computer systems are stressed throughout the curriculum. The modern computer facilities and on-going research in the application of computer systems in the solution of current military problems provide the graduate with the education necessary for productive achievement throughout his future military career.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Students lacking these quantitative prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success such as the Graduate Record Examination (GRE), Admission Test for Graduate Schools of Business (ATGSB), or Graduate Management Admission Test (GMAT) indicate a capability for graduate level work.

DESCRIPTION — The Computer Systems curriculum is an interdisciplinary program which integrates mathematics, accounting, economics, computer science, behavioral science, and management techniques into an understanding of the technical management of large computer centers. Program flexibility is available to permit a student to pursue, in depth, a specialization in an area of interest to himself and his Service community. Completion of the computer systems program requires five quarters (1¼ years) or less depending on the student's academic background, experience and ability. Requirements for the Master of Science in Computer Systems Management are met as an included part of the curricular program. In addition, Naval officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Systems curriculum is in September and March; however, on a case basis students may commence their program in January or July through prior preparation and careful coordination with the Curricular Office.

The typical student at the Naval Postgraduate School is returning to a formal academic program after several years of operational military duty. Since the needs of the military service often dictate that an officer's graduate work is in a field different from his undergraduate major, the five quarter program includes a certain amount of introductory material in the first quarter as a foundation for graduate study in Computer Systems. This introductory work is designed to bring all students up to a common level. Upon entry into the program, an evaluation of each student's prior academic work and related military experience is coordinated through the Curricular Office. As a result of this evaluation, academic credit for courses previously completed and applicable to the Computer Systems curriculum will be transferred. In addition, validation is encouraged where knowledge of the material has been acquired by recent academic work or experience. Through these procedures, it is expected that in many cases, the introductory work need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter. Any transfer of applicable credit is used to reduce the number of courses taken in the program and the length of the program.

PROGRAM — The model curriculum includes the following comprehensive fields:

Mathematics: provides the quantitative tools necessary for management of systems.

MA 2300	Math for Management	5-0
PS 3011	Probability and Statistics for Management I	5-0
OS 3210	Operations Research for Computer Systems Managers	4-0

Financial Management: provides the fundamentals necessary for effective management of resources.

MN 3155	Financial and Managerial Accounting	4-0
MN 3143	Managerial Economics	4-0
MN 3170	Defense Resource Allocation	4-0

Computer Fundamentals: provides the basics of computer hardware, software, and systems.

CS 3010	Computing Devices and Systems	3-0
CS 3020	Program Development: Structure, Design and Languages	3-4
CS 3030	Operating Systems Structures	5-0
CS 4200	Systems Analysis and Design	4-0
CS 4300	Data Base Systems	4-0

Computer Management: provides basic management techniques as applied to management of large computer centers.

CT 2000	Introduction to Computer Management	3-2
MN 2106	Individual and Group Behavior	4-0
MN 3105	Organization and Management	4-0
CT 3220	Computer Center Operations	3-2
CT 4185	Computer-Based Management Information Systems	4-0
CT 4182	Data Processing Management	4-0

Electives: provides an opportunity to explore a subject in depth to meet curriculum sponsor's needs and to develop professionally. Selection of electives is done in cooperation with, and by approval of, the Curricular Office. At least three electives must be taken, one of them at the 4000 level. If desired, a thesis may be undertaken in lieu of two electives. These electives include additional offerings in computer science, operations research, personnel/manpower, financial management, material/logistics, and economics.

COMPUTER SCIENCE CURRICULUM
CURRICULUM NUMBER 368
(GROUP CS)

OBJECTIVE — To provide a graduate with the knowledge and skills necessary to specify, evaluate, and manage the design of computer systems and to provide technical guidance in applications ranging from basic data processing to sophisticated tactical systems. This program is designed to meet the needs of the Military Services for an officer with graduate education in applied computer science. The application of computers to all aspects of military operations is stressed throughout the

curriculum. The program emphasizes the analysis and design methodologies appropriate to an understanding of the hardware and software components of complex computer systems. The modern computer laboratory facilities and associated research in the application of computer techniques to current military problems provide the graduate with unequalled opportunities for productive achievement throughout his future military career.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree or the equivalent with above average grades in mathematics is required. Completion of differential and integral calculus is considered minimal preparation. Undergraduate majors in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination, indicate a capability for work in quantitative subjects. Documented practical experience in the computer field will also enhance a candidate's potential for admission.

DESCRIPTION — Computer Science is a relatively new academic discipline, concerned with the representation, storage and manipulation of data by techniques and devices applicable to a wide variety of problems. This curriculum is an interdisciplinary program integrating mathematics, probability, statistics, operations research, and electronics in addition to computer hardware and software theory and applications. Completion of the Computer Science program requires seven academic quarters (1¾ years) or less, depending on the student's academic background, experience, and ability. Requirements for the Master of Science in Computer Science are satisfied as part of the curricular program. In addition, Naval officers will be awarded the appropriate subspecialty code upon successful completion of the program.

Normal input for the Computer Science curriculum is in September and March; however, on an individual case basis students may commence their program in January and July through prior preparation and careful coordination with the curricular office.

The typical student at the Naval Postgraduate School is returning to a formal academic program after several years of operational military duty. Since the needs of the military services often dictate that an officer's graduate work is in a field different from his undergraduate major, the seven quarter program includes a certain amount of introductory material which precedes the graduate study in Computer Science. This introductory work is found in the preparatory phase of the program. This portion of the program varies from zero to two quarters in length depending on the student's background, prior education, and length of time away from formal academic work.

The graduate program in Computer Science requires four to five quarters to complete. At the beginning of the graduate phase of the curriculum a student elects an option area in which to concentrate his studies. The option areas presently available are Tactical Computer Systems, Computer Software, and Military Data Processing.

Upon entry into the program, an evaluation of each student's prior academic work and related military experience is coordinated through the Curricular Office. As a result of this evaluation, academic credit for courses previously completed and applicable to the Computer Science curriculum will be transferred. In addition, validation is encouraged where knowledge of the material has been acquired by previous recent academic work or experience. Through these procedures, it is expected that, in many cases, the preparatory material need not be taken at the Naval Postgraduate School. The remaining courses will be programmed with a nominal course load of 16 credit hours per quarter.

PREPARATORY STUDY — The preparatory phase of the curriculum provides the necessary background and tools required for successful pursuit of graduate study in Computer Science. This portion of the program varies in length depending on the amount of course work listed below which can be satisfied by prior academic work. Descriptions of the courses appear in the departmental listings of this catalog. A review of elementary calculus and work in computer programming involving a higher-level language and assembly language prior to matriculation at the Postgraduate School is strongly urged.

Mathematics

MA 1100	Calculus and Vector Analysis	5-2
MA 2045	Computational Matrix Algebra	3-0
MA 2121	Differential Equations	4-0

Logic

MA 2025	Logic, Sets, and Functions	4-0
MA 3026	Topics in Discrete Mathematics	4-0

Probability and Statistics

PS 3414	Applied Probability and Statistics	4-0

Computer Fundamentals

CS 2100	Introduction to FORTRAN Programming	1-2
CS 2103	Introduction to COBOL Programming	1-2
CS 2110	Introduction to Computers and Programming for Computer Science Majors	3-2
EE 2810	Digital Machines	3-3
CS 3111	Fundamental Concepts in Structural Programming Languages	4-0

GRADUATE STUDY — The graduate phase of the curriculum consists of required core courses, option area courses, elective courses, and thesis research. Any transfer of applicable graduate credit is used to reduce the number of courses taken in the program and the length of the program.

Core Courses

CS 3112	Operating Systems	4-0
CS 3300	Information Structures	3-0
CS 3113	Introduction to Compilers	3-0
CS 4112	Computer Systems	4-0
CS 4113	Compiler Design and Implementation	3-2
CS 4200	System Analysis and Design	4-0
CS 4300	Data Base Systems	4-0
CT 4182	Data Processing Management	4-0
OS 3205	Operations Research for Computer Scientists	4-0
MA 3232	Numerical Analysis	3-2

Option Courses – Three courses chosen from a particular option area are required. The options offer a degree of specialization in a particular area in recognition of a student's Military Service requirements. The selection of the option area and the courses is made in consultation with the Curricular Office.

Tactical Computer Systems

CS 3510	Real Time Combat Systems and Structures	3-2
CS 3230	Microcomputers	3-2
CS 4202	Interactive Computation Systems	3-2
CS 3204	Data Communications	4-0

Computer Software

CS 4300	Data Base Systems	4-0
CS 3310	Artificial Intelligence	4-0
OA 3653	System Simulation	4-0
CS 3230	Microcomputers	3-2
CS 3020	Program Development: Structure, Design, Language	3-4

Military Data Processing

CT 3220	Computer Center Operations	3-2
CT 4185	Computer Based Management Information Systems	4-0
MN 3170	Defense Resource Allocation	4-0
CM 3184	Real-Time Information Systems	4-0

Elective Courses – Elective courses are available to broaden the student's education in an area of interest. Selection of electives is done in cooperation with, and approval of the Curricular Office. Four electives are available in areas such as management, electrical engineering, operations analysis, mathematics, computer science, oceanography, and aeronautical engineering.

Thesis Research – Sixteen quarter hours are allocated for thesis research, eight in each of the student's final two quarters of the program. Emphasis is on military applications and research in the computer science field. The thesis subject will be appropriate to the option area selected.

ELECTRONICS AND COMMUNICATIONS PROGRAMS CURRICULA NUMBERS 590, 591, 595, 600, 620/620CG

CARLYSLE JOHN THOMAS, Commander, U.S. Navy; Curricular Officer; B.S., Univ. of Arizona, 1959; M.S. in Management, Naval Postgraduate School, 1974.

ABRAHAM SHEINGOLD, Academic Associate for Electronics/Communications Engineering; B.S., College of the City of New York, 1936; M.S., 1937.

NORMAN FLOYD SCHNEIDEWIND, Academic Associate for Telecommunications Systems; B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (Engr.), 1970; D.B.A., 1966.

DAVID BOYSEN HOISINGTON, Academic Associate for Electronic Warfare Systems Technology; B.S.E.E., Massachusetts Institute of Technology, 1940; M.S., Moore School of Electrical Engineering, 1941.

ALLAN WILEY TULLOCH, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1967; M.S. in Management, Naval Postgraduate School, 1972.

OBJECTIVE — The Electronics and Communications Programs include curricula designed to satisfy the needs of the service and the interests of the officers in these fields. Successful completion of a curriculum leads to the award of the degree of Master of Science or a higher degree in the principal field. This education permits the officer to address more knowledgeably current and future military problems associated with electronic/communications systems, and expands his base of professional knowledge and technical competence in his subspecialty area. It is designed to enhance performance in all duties throughout a naval career including operational billets, technical management assignments, and the policy making positions.

Within the broad fields of electronics and communications, various option tracks are available after completing the graduate core requirements. Successful completion of the Engineering Electronics, Communications Engineering or Electronic Warfare Engineering Curricula leads to an appropriate Navy subspecialty code, and each curriculum includes all requirements for the degree Master of Science in Electrical Engineering. The Electronic Warfare Systems Technology Curriculum results in an Electronic Warfare subspecialty code, and meets requirements for the degree Master of Science in Systems Technology. In the Telecommunications Systems Curriculum, the Communications Systems Technology subspecialty code is earned, and the requirements for the degree Master of Science in Management are met. All curricula provide the officer with a well-rounded knowledge of the scientific principles, technical practices and managerial/analytical skills pertinent to his field of study. The officer's studies also serve to produce a heightened capacity for creative thought and innovative problem solving. The curricula provide latitude for studies in associated areas outside the field of specialization to accommodate the academic background and individual interests of the officer and help him acquire diverse professional knowledge, a new appreciation for continuing education, an added awareness of the many complex elements of problems, and an enhanced personal confidence conducive to productive achievement throughout his naval career.

ENGINEERING ELECTRONICS CURRICULUM CURRICULUM NUMBER 590

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with com-

prehensive scientific and technical knowledge in the field of electronics as applied to Navy systems.

ELECTRONIC WARFARE ENGINEERING CURRICULUM
CURRICULUM NUMBER 591

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with a comprehensive scientific and technical knowledge in the field of electronic warfare engineering as applied to Navy systems.

COMMUNICATIONS ENGINEERING CURRICULUM
CURRICULUM NUMBER 600

OBJECTIVE (SPECIFIC) — To provide officers, through graduate education, with a comprehensive scientific and technical knowledge in the field of communications engineering as applied to Navy and Defense Command, Control and Communication Systems.

ELECTRONIC ENGINEERING, ELECTRONIC WARFARE ENGINEERING, AND COMMUNICATIONS ENGINEERING CURRICULA
CURRICULA NUMBERS 590, 591, AND 600

QUALIFICATIONS FOR ADMISSION — Prior baccalaureate degree including above average grades in differential/integral calculus and general physics. Those lacking this background may matriculate via the Engineering Science program.

DESCRIPTION — These curricula are designed to establish a broad background of basic engineering knowledge leading to selected advanced studies in electronic systems, communications, electronic warfare, ship/weapon control systems, information processing or other pertinent areas of professional applicability. Classes convene semiannually, in March and September.

The graduate-studies portion of the program is normally of twelve months duration. It is preceded by an introductory core program which is designed to provide a smooth transition from previous studies and experience. For entering students who have a non-engineering background, except as stated in the qualifications above, and who have been absent from academic studies for five or more years, the background studies may be of up to five quarters duration, leading to a complete program duration of twenty-seven months. For students with better entrance qualifications, special review courses and course validations enable them to complete the total program in eighteen, twenty-one or twenty-four months.

Toward the end of their preparatory program, officers are evaluated for academic progress and potential to complete the advanced degree portion of the curriculum. Those officers who have demonstrated a capability to satisfy academic requirements for the Master of Science degree will continue in the master's program and select an appropriate area of subject specialization and thesis research. Academically superior students may be selected, subject to service needs and approval, for further advanced studies leading to the degree of Electrical Engineer, Doctor of Engineering or Doctor of Philosophy. Those officers who are unable to continue in graduate-level studies will pursue a shortened terminal program beyond the basic core. An appropriate subspecialty code will be granted to the few officers in this category.

INTRODUCTORY CORE

This portion of the program provides a sound academic background in mathematics, computer science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. The courses which are not validated will be programmed using a nominal course load of 16-18 credit hours per quarter.

Mathematics

MA 1100	Calculus and Vector Analysis	5-2
MA 2045	Computational Matrix Algebra	3-0
MA 2121	Differential Equations	4-0
MA 2172	Complex Variables	4-0

Physics

PH 1041	Review of Mechanics and Electricity and Magnetism	5-1
PH 2241	Wave Phenomena	4-0
PH 2641	Atomic Physics	4-2

Circuits and Systems

EE 2101	Basic Circuit Theory	3-2
EE 2102	Circuit Analysis	4-2
EE 2103	Linear Systems Analysis	4-2
EE 2411	Control Systems	3-3

Electronics

EE 2211	Electronics Engineering Fundamentals I	4-2
EE 2212	Electronics Engineering Fundamentals II	4-3
EE 2216	Pulse and Digital Circuits	4-3

Computers

CS 2700	Introduction to Computer Programming with FORTRAN	2-2
EE 2810	Digital Machines	3-3

Electromagnetics

EE 2621	Introduction to Fields and Waves	4-0
EE 2622	Electromagnetic Engineering	3-1

Communications

EE 2114	Communications Theory	4-0
EE 2217	Communication Circuits	4-3

GRADUATE STUDY

The advanced studies program leading to a master's degree is individually designed to be academically sound, consistent with the needs of the service and responsive to the interests and objectives of the officer. The program consists of courses in required subject areas, elective courses in coherent and relevant option areas and thesis research. The degree requirements include the completion of 40 credit hours of approved graduate study. The additional thesis research normally occupies the time equivalent for four courses, allocated during the final three quarters of the program. Any transfer of graduate credit which is applicable may be used to reduce the number of programmed courses.

The Graduate Core

To provide a well rounded graduate program, all students are required to include courses in the subject areas of advanced electronics, signal processing, stochastic processes and advanced systems. Representative courses include the following:

EE 3571	Stochastic Analysis of Signals	4-1
EE 3215	Microwave Devices	4-2
EE 3263	Integrated Electronics	3-3
EE 4121	Advanced Network Theory	3-2
EE 4572	Statistical Communication Theory	3-2
EE 3631	Electromagnetic Radiation and Compatibility	4-2
EE 4461	Advanced Systems Engineering	3-1

Option Electives

The graduate program also includes a course sequence in a selected area. Listed below are representative electives associated with particular areas of professional applicability. Considerable latitude is permitted in specific elective selections, with the choices approved on the basis of consistency of the overall program with professional applicability and an agreement with academic requirements.

Representative Electives

Communications

(required for 600 program)

EE 3422	Modern Communications	3-2
EE 4575	Advanced Digital Methods in Communication Systems	4-2
EE 4581	Information Theory	3-2
EE 4591	Communication Satellite Systems Engineering	3-2

Ship/Weapon Control Systems

EE 3311	Energy Conversion	3-2
EE 4473	Missile Guidance Systems	3-1
EE 4418	Ship Control Systems	3-2
EE 4412	Nonlinear and Discrete Systems	3-3
EE 4411	Digital Control Systems	3-2
EE 4433	Advanced Radar Systems	3-2
EE 4413	Optimal Linear Estimation and Control	3-2

Electronic Warfare

(required for 591 program)

EE 4433	Advanced Radar Systems	3-2
EE 4481	Electronic Warfare Techniques and Systems	3-3
EE 4482	Signals Intelligence (SIGINT) Systems Engineering	2-2
EE 4473	Missile Guidance Systems	3-1
EE 3631	Electromagnetic Radiation and Compatibility	4-2

Information Processing

EE 4581	Information Theory	3-2
EE 4575	Advanced Digital Methods in Communications Systems	4-2
EE 3420	Engineering Fundamentals of Electro-Optics	3-1

EE 3822	Engineering Applications of Computers	3-3
EE 4422	Electro-Optic System Engineering	3-1

Digital Systems Engineering

EE 3812	Switching Theory & Logic Design	3-2
EE 3822	Engineering Applications of Computers	3-3
EE 4823	Advanced Digital Computer Systems	3-1
CS 4202	Interactive Computation Systems	3-2
EE 4545	Digital Filters	3-2
EE 4575	Advanced Digital Methods in Communication Systems	4-2

Bioengineering

EE 3801	Human Physiology	5-0
EE 3820	Bioelectronic Instrumentation	3-3
EE 4890	Computer Modeling of Biological Systems	2-4
EE 4880	Advanced Topics in Human Physiology	4-0

The following interdisciplinary or professional development courses are available under any option:

OS 3203	Survey of Operations Analysis/ Systems Analysis	4-0
AS 3204	Defense Resource Analysis	4-0
AS 3501	Project Management	4-0
MN 3811	Communications in Organizations	4-0
MN 3155	Financial and Managerial Accounting	4-0

ELECTRICAL ENGINEER

As determined by service needs and superior academic achievement, officers may matriculate into a program leading to the advanced degree Electrical Engineer. This advanced graduate program requires approximately seven quarters of work beyond the Introductory Core. The scope of graduate study is greatly increased over the Master of Science curriculum and a thesis of greater depth is required. In addition, the officer may be provided an opportunity for an industrial experience tour of up to 12 weeks duration.

ELECTRONIC WARFARE SYSTEMS TECHNOLOGY CURRICULUM NUMBER 595

OBJECTIVE (SPECIFIC) — To provide the service with sufficient officers thoroughly knowledgeable in the technical and operational aspects of both the art and the role of Electronic Warfare as a vital, integral part of modern warfare.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces. Admission to the curriculum requires a Baccalaureate Degree with above average grades. Completion of mathematics through differential and integral calculus is required. Students lacking this background may matriculate via the Engineering Science Program. Although designed primarily for unrestricted line officers with established warfare qualifications, quotas may be available on a case basis for officers of the restricted line communities. Of importance equal to academic qualifications is demonstrated outstanding performance in an officer's warfare specialty. A tour of duty providing operational electronic warfare experience is also desirable but not mandatory. Officers selected for the 595 Curriculum must be eligible for security clearances permitting access to sensitive intelligence information.

DESCRIPTION — This curriculum is designed to provide an understanding of the principles underlying the broad field of electronic warfare. Because of the electronic nature of modern sensor, weapon and command, control and communication systems, this curriculum seeks to develop in the officer a grasp of electronic, electrical and electromagnetic fundamentals, theory and techniques. Another principal goal of the 595 Curriculum is to develop an ability to describe technological factors in terms which are meaningful and supportive in an operational or tactical situation. To achieve these aims, preparatory material in mathematics, operations research, probability, statistics, physics and computer science are included in the program.

The 595 Curriculum is highly interdisciplinary and comprises several tracks. Inputs will occur annually in March. Each officer's transcript of prior baccalaureate study is evaluated to eliminate unnecessary duplication of previously covered material.

INTRODUCTORY CORE

This portion of the program provides a sound academic background in mathematics, computer

science and technology, physics and electrical engineering. Each student's prior academic transcripts will be evaluated for validation of as many of these courses as possible. The courses which are not validated will be programmed using a nominal course load of 16-18 credit hours per quarter.

Mathematics

MA 1119	Selected Calculus Topics Review	2-1
MA 2129	Ordinary Differential Equations and LaPlace Transforms	2-1
MA 2181	Vector Calculus	2-1
MA 3139	Fourier Analysis and Partial Differential Equations	4-0
PS 3411	Applied Probability Theory I	4-1

Physics

PH 2123	Basic Physics	4-0
PH 2270	Fundamentals of Electro-Optics	4-0

Computer Science

CS 2700	Introduction to Computer Programming with FORTRAN	2-2
CS 3510	Real-Time Combat Direction Systems and Structures	3-2

Naval Intelligence

NS 2070	Naval Warfare and National Security	4-0

Basic Electrical Engineering

EE 2721	Introduction to Electronics Systems	4-1
EE 3714	Introduction to Signals and Noise	4-1
EE 2225	Pulse and Digital Circuits	2-1
EE 2418	Control Systems	2-1
EE 2624	Electromagnetic Theory	4-1

Operations Analysis

OS 3661	Decision Analysis and Data Analysis	4-0
OS 3655	Simulation and War Gaming	2-2

Meteorology

MR 2416	Meteorology for Electronic Warfare	2-0

GRADUATE STUDY

The Operational Electronic Warfare Curriculum qualifies the student for the degree Master of Science in Systems Technology. During the last three quarters of this eight-quarter (two-year) program the officer undertakes thesis research and preparation on a topic relevant to current military electronic warfare efforts. A program of seminars given by representatives of EW-oriented activities and industry supplements classroom instruction.

Electrical Engineering

EE 4434	Microwave Devices and Radar	4-2
EE 4716	Signal Processing Systems	4-1
EE 3625	Electromagnetic Radiation, Scattering, and Propagation	4-2
EE 4484	Electronic Warfare Systems	3-2

Electro-Optics

PH 3271	Electro-Optic Principles and Devices	4-0
EE 4423	Electro-Optic Systems and Countermeasures	3-1

Operations Analysis

OS 3665	Human Vigilance Performance	3-1
OS 3208	Operations Analysis for Electronic Warfare	4-0
OS 4653	Operational Test and Evaluation	4-0

Systems Technology

ST 3020	Electronic Warfare Computer Applications	3-2
ST 3350	Signal Intelligence and the Threat Environment	4-0
ST 4453	Underwater Sound, Systems, and Countermeasures	3-2
MN 3811	Communications in Organizations	4-0

TELECOMMUNICATIONS SYSTEMS CURRICULA CURRICULUM NUMBERS 620 AND 620CG

OBJECTIVE (SPECIFIC) — To provide instruction to officers who will perform as Communications Managers of new communications

systems applications or as Communications Officers in large commands and staffs, afloat and ashore, including the organization of the Joint Chiefs of Staff and the Defense Communications Agency.

QUALIFICATIONS FOR ADMISSION — Admission to the curricula requires a Baccalaureate Degree with above average grades. Completion of mathematics through college algebra and trigonometry is required for the 620 curriculum. The student must be ready to start calculus courses on enrollment. The qualifications for the 620CG curriculum are the same as the 590 and 600 curricula.

DESCRIPTION — The 620 and 620CG curricula are sponsored respectively by the Director, Naval Communications and U.S. Coast Guard Headquarters. Each curriculum provides comprehensive study in management, with emphasis upon the systems management field. Additionally, the curricula provide study in the technical field appropriate to decision making in advanced system and program management. These technical courses within the 620 curriculum have been especially prepared for non-engineers whereas those in the 620CG curriculum are engineering courses. Classroom instruction is supplemented by guest lecturer seminars which afford the student an opportunity to hear discussions of communications topics by military officers and civilian executives from the Naval Telecommunications Command, Defense Communications Agency, National Security Agency and other major communications activities.

The 620 classes convene in September. Students are accepted for the 620CG curriculum in either March or September. Each student's prior academic transcript is evaluated for validation of courses or for transfer of credit to cover as many courses as possible. Validation is also encouraged for courses whose content has been acquired by experience or service courses.

620 (NAVY) CURRICULUM

Quantitative Methods. Provides the quantitative tools necessary for analyzing problems in telecommunications systems management and for conducting thesis research.

MA 2300	Mathematics for Management	5-0
MA 2040	Matrix Algebra	2-0
PS 3011	Probability and Statistics for Communications Management	5-0
OS 3211	Operations Research for Communications Managers	4-0

Electronics. Provides a non-engineering approach to communications systems. Courses are designed to give the prospective manager sufficient knowledge to be able to discuss and understand communications technology, communications systems, signal transmission systems and systems analysis.

EE 2421	Introduction to Communications Technology	4-2
EE 2422	Communications Systems I	4-3
EE 2810	Digital Machines	3-3
EE 2424	Signal Transmission Systems	4-2
EE 3425	Communications Systems Analysis	3-3

Financial Management and Economic Analysis. Provides the accounting and economic analysis aspects of military resource allocation problems.

MN 3155	Financial and Managerial Accounting	4-0
MN 3143	Managerial Economics	4-0
MN 3170	Defense Resource Allocation	4-0

Behavioral Science. Provides material on individual and group behavior and social problems in the military. The student is acquainted with contemporary problems of race and inter-cultural relations in the military establishment.

MN 2106	Individual and Group Behavior	4-0
MN 3812	Communication in Organizations	4-0

Organization and Management. Provides organizational aspects of the DOD telecommunications establishment, DOD procurement policies and management planning and control.

MN 3105	Organization and Management	4-0
MN 3371	Procurement and Contract Administration	4-0
CO 2111	Defense Communications Organization and Planning	

CO 3112 Integrated Defense Telecommunications Systems 3-2

Information Systems. Provides an overview of computer hardward and software concepts and the computer-controlled aspects of message and data communications systems.

CS 2103 Introduction to Cobol Programming 1-2
CM 3184 Real Time Information Systems 4-0
CM 4184 Real Time Information System Management 4-0

Electives. Provides the student with an opportunity to pursue his own area of special interest.

MN 4105 Management Policy 4-0
MN 4133 Economics of Computers 4-0
MN 4151 Internal Audit and Control 4-0
CT 4185 Computer-Based Management Information Systems 4-0
MN 4371 Procurement Policy 4-0

Thesis. The student has the opportunity to apply the course material to a practical military telecommunications problem during the last two quarters of the program.

620CG (COAST GUARD) CURRICULUM

Quantitative Methods. Provides the quantitative tools necessary for analyzing communications management and engineering problems.

MA 1100 Calculus and Vector Analysis 5-2
MA 2045 Computational Matrix Algebra 3-0
MA 2121 Differential Equations 4-0
MA 2172 Complex Variables 4-0
PS 3411 Applied Probability Theory I 4-1
OS 3211 Operations Research for Communications Managers ...4-0
OA 4633 Networks Flows and Graphs 4-0

Electronics. Provides extensive coverage of electronics and communications engineering.

EE 2101 Basic Circuit Theory 3-2
EE 2102 Circuit Analysis 4-2
EE 2211 Electronic Engineering Fundamentals I 4-2
EE 2103 Linear Systems Analysis 4-2
EE 2114 Communications Theory I 4-0
EE 2212 Electronic Engineering Fundamentals II 4-3
EE 2621 Introduction to Fields and Waves 4-0
EE 2622 Electromagnetic Engineering ...3-1
EE 3422 Modern Communications 3-2
EE 3631 Electromagnetic Radiation and Compatibility 4-2
EE 4572 Statistical Communication Theory 3-2

Financial Management and Economic Analysis. Provides the accounting and economic analysis aspects of military resource allocation problems.

MN 3155 Financial and Managerial Accounting 4-0
MN 3143 Managerial Economics 4-0
MN 3170 Defense Resource Allocation 4-0

Organization and Management. Provides the behavioral, procurement and management planning and control aspects of military communications.

MN 2106 Individual and Group Behavior 4-0
MN 3105 Organization and Management 4-0
MN 3371 Procurement and Contract Administration 4-0

Information and Computer Systems. Provides the computer hardware and software design concepts and the computer-controlled aspects of message and data communication systems.

CS 2700 Introduction to Computers and FORTRAN Programming .2-2
CS 3200 Structure of Digital Computers 4-0
CM 3184 Real Time Information Systems 4-0
CM 4184 Real Time Information System Management 4-0
CT 4185 Computer Based Management Information Systems 4-0

Electives. Provides the student with an opportunity to pursue his own area of special interest. Representative electives are:

MN 3121	Leadership and Group Behavior	4-0
MN 4105	Management Policy	4-0
MN 3124	Analysis of Bureaucracy	4-0
MN 4371	Procurement Policy	4-0
MN 4151	Internal Audit and Control	4-0
MN 4133	Economics of Computers	4-0
EE 4591	Communication Satellite Systems Engineering	3-2

Thesis. The student has the opportunity to apply the course material to a practical Coast Guard telecommunications problem during the last two quarters of the program.

ENGINEERING SCIENCE PROGRAM

OBJECTIVE — To provide officers who desire and are selected for an advanced technical education, but who are deficient in mathematics and the physical sciences, an opportunity to qualify for admission into one of the graduate level technical programs at Naval Postgraduate School.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with a C+ average, completion of at least two pre calculus mathematics courses with a B average, or at least one course in calculus with a C grade and at least one course in physics.

DESCRIPTION — Officers ordered to this preparatory curriculum are assigned to the curricular office of the graduate curriculum they have been selected to attend. Each officer selects courses to correct his personal deficiencies, concentrating on basic mathematics, physical science and courses in the preparatory part of his graduate curriculum.

Normal input to the curriculum occurs in March and September, with a planned duration of two quarters. Inputs can be accepted at other dates dependent on the starting dates for the graduate curriculum to be followed.

ENVIRONMENTAL SCIENCES PROGRAMS CURRICULA NUMBERS 372, 373, AND 440

JERRY DEAN JARRELL, Commander, U.S. Navy: Curricular Officer; B.S., Concord College, 1956; M.S. in Meteorology, Naval Postgraduate School, 1965; M.S. in Management, 1973.

ROBERT GEORGE PAQUETTE, Academic Associate (Oceanography); B.S., Univ. of Washington, 1936; Ph.D., 1942.

ROBERT JOSEPH RENARD, Academic Associate (Meteorology); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

JOHN SAVERIO KOLODZIEJ, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., Univ. of Notre Dame, 1961; M.S., Naval Postgraduate School, 1968.

METEOROLOGY CURRICULUM CURRICULUM NUMBER 372

OBJECTIVE — To provide qualified personnel with a sound understanding of the science of meteorology and to develop the technical expertise to provide, and utilize, meteorological and oceanographic data in support of all aspects of military operations.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments, and policy making positions. Personnel will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their professional career.

QUALIFICATIONS FOR ADMISSION* — A baccalaureate degree with at least average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation.

** This curriculum is not open to U.S. naval officers. The program is open to Air Force Officers, Allied Officers, and qualified federal employees.*

DESCRIPTION — The Meteorology Curriculum is interdisciplinary in nature and encompasses those areas of meteorology which are directly related to environmental support of operations. The program consists of preparatory subjects, a sequence in synoptic and numerical meteorology, and a sequence of courses in dynamic meteorological processes. The program recognizes the interaction of the atmosphere and the ocean mass and deals with their relationships at the air/sea interface.

Classroom instruction is supplemented by laboratory exercises, computer solutions to problems, and guest lectures and seminars. Upon completion of the program, the student is qualified to serve independently as a meteorological forecaster. By completing a required thesis, he is introduced to the problems associated with independent research. Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology.

Matriculation may occur any quarter each year. Although the program is designed for eight academic quarters, students qualified may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

Preparatory Courses: provides the academic tools necessary for successful pursuit of the remaining courses.

MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MA 3132	Partial Differential Equations & Integral Transforms	4-0
MA 3232	Numerical Analysis	3-2
MR 2210	Marine Meteorology	4-3
MR 2520	Climatology and Statistics	3-1
OC 2120	Survey of Oceanography	4-0

Synoptic and Numerical Meteorology Sequence:

MR 3150	Geophysical Random Processes	3-1
MR 3212	Polar Meteorology/ Oceanography	3-1
MR 3220	Meteorological Analysis	3-0
MR 3225	Meteorological Analysis Laboratory	0-6
MR 3230	Tropospheric and Stratospheric Meteorology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-8
MR 3252	Tropical Meteorology	3-4
MR 3262	Prognostic Charts and Forecasting Weather Elements	3-4
MR 4241	Mesoscale Meteorology	3-0
MR 4323	Numerical Air and Ocean Modeling	4-3

Dynamic Meteorology Sequence:

MR 3321	Air-Ocean Fluid Dynamics	4-0
MR 3420	Geophysical Thermodynamics	4-0
MR 3421	Cloud Physics	3-0
MR 3512	Heat Transfer Processes	4-0
MR 4322	Dynamic Meteorology	4-0
MR 4413	Air/Sea Interaction	4-0

Thesis Preparation: Ample time is provided for the student to complete research for a thesis in the area of his primary interest. Elective courses are also available in air-ocean science or related fields.

AIR-OCEAN SCIENCE CURRICULUM CURRICULUM NUMBER 373

OBJECTIVE — To provide qualified personnel with a thorough understanding of the air-sea environment and to develop the technical expertise to provide and utilize meteorological and oceanographic data and knowledge in support of all aspects of military operation.

This education enhances performance in all duties throughout a career including operational billets, technical management assignments and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their careers.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree in meteorology, or oceanography, or the equivalent. Provision is made for lesser qualified students to enter via the Oceanography Curriculum (#440). While this curriculum is open to officers of the other U.S. military services, allied officers, and U.S. federal employees, its availability to U.S. Navy officers is limited to those of the Restricted Line (Special Duty — Geophysics). Additionally, Navy officer students in the Oceanography Curriculum may, upon change of designator, transfer into the Air-Ocean Science Curriculum.

DESCRIPTION — The Air-Ocean Curriculum (#373) is interdisciplinary in nature and encompasses those areas of meteorology and oceanography which are directly related to environmental support of military operations. The program consists of preparatory subjects, basic courses in dynamic and physical meteorology and oceanography, and a sequence in environmental analysis and forecasting, including numerical methods by computer. The program recognizes the importance of interactions between the atmosphere and the oceans, and deals with their relationships at the air/sea interface.

Classroom instruction is supplemented

by laboratory exercises, field experience, computer solutions to problems, and guest lectures and seminars. Each student is required to complete a satisfactory thesis. In so doing the student is introduced to the problem of applying his theoretical knowledge to the solution of a practical problem. Upon completion of the program, the student is qualified to serve independently as a meteorological and oceanographic forecaster in support of operations.

Matriculation may occur any quarter each year. A typical program for students with a baccalaureate degree in either meterology or oceanography is eight quarters. However, students may have this period shortened by validation of courses previously taken, transfer of credits, and by evaluation of the level of previous experience in the field.

Successful completion of the program leads to the awarding of the degree of Master of Science in Meteorology and Oceanography.

Typical Program:

Preparatory Phase (Student is expected to require four courses from this group)

CS 2700	Introduction to FORTRAN	2-2
MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MR 2210	Marine Meteorology	4-3
MR 3220	Meteorological Analysis	3-0
MR 3225	Meterological Analysis Laboratory	0-6
MR 3420	Geophysical Thermodynamics	4-0
OC 3220	Physical Oceanography I	3-0
OC 3320	Geological Oceanography	3-3
OC 3420	Biological Oceanography	3-3
OC 3520	Chemical Oceanography	3-3
PS 2501	Introduction to Probability and Statistics	4-0

Curriculum Core

MA 3132	Partial Differential Equations	4-0
MA 3232	Numerical Analysis	3-2
MN 3811	Communications in Organizations	4-0
MR 3230	Tropospheric and Stratospheric Meterology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-8
MR 3252	Tropical Meteorology	3-4
MR 3262	Prognostic Charts and Forecasting Weather Elements	3-4
MR 3321	Air-Ocean Fluid Dynamics	4-0
MR 3512	Heat Transfer Processes	4-0
MR 4322	Dynamic Meteorology	4-0
MR 4323	Numerical Air and Ocean Modeling	4-3
MR 4413	Air/Sea Interaction	4-0
MR/OC 0810	Thesis Research	0-0
MR/OC 4900	Thesis Seminar	2-0
OC 3150	Geophysical Random Processes	4-2
OC 3221	Physical Oceanography II	3-0
OC 3321	Marine Geophysics	3-0
OC 3621	Regional Military Oceanography	1-4
OC 4211	Waves and Tides	4-0
OC 4213	Coastal Oceanography	3-2
OC 4260	Sound in the Sea	4-0
OC 4322	Ocean Dynamics	4-0
PH 3431	Physics of Sound in the Ocean	4-2

Elective Area List I (Two courses required)

MR 3421	Cloud Physics	3-0
MR 4241	Mesoscale Meteorology	3-0
MR 4416	Atmospheric Factors in Electromagnetic Propagation	3-0
MR/OC 3212	Polar Oceanograpy and Meterology	3-1
OC 3610	Ocean Wave Forecasting	2-2
OC 3617	Acoustical Forecasting	2-2
OC 3801	Ocean Operations I	3-1

Elective Area List II (Two courses required)

Any from List I
Advanced Meteorology
Advanced Oceanography
Advanced Mathematics
Operations Analysis
Computer Systems
Management
International Law and Ocean Policy
Environmental Quality
Electronics

Communications
Underwater Acoustics

OCEANOGRAPHY CURRICULUM CURRICULUM NUMBER 440

OBJECTIVE — To provide students with a sound understanding of the science of physical oceanography, and to develop the technical expertise to provide and utilize oceanographic and acoustical data in support of all aspects of military operations. Particular emphasis is placed on the understanding of oceanographic environmental effects on the solution of the Antisubmarine and Undersea Warfare problems.

Students who successfully complete this curriculum will be awarded an appropriate subspecialty billet code. However, this education enhances performance in all duties throughout a military career including operational billets, technical management assignments, and policy making positions. Students will develop sound graduate level technical ability based on general engineering and scientific principles, build a new appreciation for continuing education, acquire diverse professional knowledge, become aware of the many complex elements of problems, develop analytical ability for practical problem solving, broaden their capacity for original thought, and discover a new personal confidence that leads to productive achievement throughout their career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with at least average grades in mathematics and the physical sciences is required. Completion of mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry is considered to be minimal preparation.

DESCRIPTION — The Oceanography Curriculum #440 is interdisciplinary in nature and encompasses a broad spectrum of physical, chemical, biological, and geological oceanography support of military operations.

Classroom instruction is supplemented by laboratory exercises both ashore and afloat. The Research Vessel ACANIA is available for class laboratory experience as well as for individual research efforts. Guest lectures, seminars, and in situ study at the Naval Arctic Research Laboratory in Barrow, Alaska, serve to round out the curriculum. Each student is required to complete a satisfactory thesis. In so doing the officer is introduced to the concept of applying theoretical knowledge toward a practical application. Successful completion of this program leads to the awarding of the degree of master of Science in Oceanography and qualifies the student to serve in any of the oceanography billets in the Department of Defense.

Matriculation may occur any quarter of the year. Although the program is designed for eight quarters, qualified students may have this period shortened by validation of courses previously taken, transfer of credits from other institutions, and by evaluation of the level of previous experience in the field.

The heart of the oceanography program consists of a basic core of graduate level courses supplemented by available electives. The knowledge of principles gained in these studies will enable the student to make beneficial applications of oceanography to future military hardware design, military tactics and strategy. As with the preparatory portion, graduate courses may be selected/validated on an individual basis. Typically included courses are:

MA 2048	Linear Algebra and Vector Analysis	5-0
MA 2121	Differential Equations	4-0
MA 3132	Partial Differential Equations and Integral Transforms	4-0
OC 3150	Geophysical Random Processes	4-2
OC 3220	Physical Oceanography I	3-0
OC 3221	Physical Oceanography II	3-0
OC 3320	Geological Oceanography	3-3
OC 3420	Biological Oceanography	3-3
OC 3520	Chemical Oceanography	3-3
OC 3709	Scientific Cruise Experience	0-4
OC 4211	Waves and Tides	4-0
OC 4213	Coastal Oceanography	3-2
OC 4321	Geophysical Fluid Dynamics	4-0
OC 4322	Ocean Dynamics	4-0
OC 4413	Sea/Air Interaction	4-0

Courses Directed Specifically to Military Applications:

OC 3820	Principles of Measurement	3-2
OC 3240	Operational Environmental Products	0-4
OC 3321	Marine Geophysics	3-0
OC 3610	Ocean Wave Forecasting	2-2
OC 3617	Acoustic Forecasting	2-2
OC 3621	Regional Military Oceanography	1-4
OC 3801	Ocean Operations I	3-1
OC 4260	Sound in the Sea	4-0
OC 4612	Polar Oceanography	3-2
PH 3431	Physics of Sound in the Ocean	4-2

NAVAL ENGINEERING PROGRAMS CURRICULA NUMBER 570

GEORGE PURVIANCE NEYMAN, III, Commander U.S. Navy; Curricular Officer; B.S., Capitol Univ., 1957; B.S.C., Webb Institute of Naval Architecture, 1966; M.S., 1966; M.S., Univ. of Rhode Island, 1972.

PAUL JAMES MARTO, Academic Associate; B.S., Univ. of Notre Dame, 1960; M.S., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

NAVAL ENGINEERING CURRICULUM CURRICULUM NUMBER 570

OBJECTIVES — To provide graduate education, primarily in the field of Mechanical Engineering, to officers from all communities. The graduate will have the technical competence to operate and maintain modern warships and weapon systems. He will be able to participate in technical aspects of naval systems acquisition and able to recognize applications for technological advances in naval ships and weapons.

ENTRANCE DATES — Classes normally convene in January, March, June and September, however, entrance at any time is possible.

QUALIFICATIONS FOR ADMISSION — mathematics through integral calculus plus one year of physics and chemistry. A baccalaureate degree or its equivalent, preferably in engineering or the physical sciences.

DESCRIPTION — the academic program is grouped into an introductory study portion and an advanced graduate level study portion. The introductory study program consist of undergraduate and graduate level courses which provide the necessary breadth and depth for successful pursuit of the advanced graduate level study portion of the program. Each student's transcript is evaluated for validation of as many of the introductory study courses as possible and the student is interviewed upon arrival to reach a final decision on those courses to be programmed for the introductory study program. The introductory study portion of the program includes courses in the following areas:

UNDERGRADUATE

Linear Algebra and Vector Analysis
Computer Programming
Ordinary Differential Equations
Engineering Materials
Statics and Dynamics
Mechanics of Solids
Engineering Thermodynamics
Fluid Mechanics
Electrical Engineering Fundamentals

GRADUATE

Partial Differential Equations
Engineering Numerical Analysis
Properties of Structural Materials
Mechanical Vibrations
Heat Transfer
Marine Power Systems
Mechanics of Structures
Survey of Nuclear Power
Hydrodynamics of Ocean Structures
Financial Management in Defense Department
Operations Research Fundamentals

After completion of the introductory study portion of the program, a meaningful set of electives are selected from the advanced graduate level courses. These are chosen in consultation with the Curricular Officer and faculty advisors. A normal program of study leading to the degree Master of Science in Mechanical Engineering will allow for five such elective courses chosen from the following extensive list:

Advanced Hydromechanics
Viscous Flow
Fluid Power Control
Fluid Machinery
Marine Gas Turbines
Conduction and Radiation Heat Transfer
Convection Heat Transfer

Design of Naval Marine Vehicles
Advanced Dynamics
Vibration, Noise and Shock
Advanced Mechanics of Solids
Finite Element Methods
Theory of Continuous Media
Properties, Problems and Failures of Structural Materials
Corrosion
Microscopy
Nuclear Reactor Analysis
Reactor Engineering Design
Laser Technology
Naval Weapons

The program of study leading to the degree Mechanical Engineer is an advanced program of graduate level studies with permits the student to further his studies beyond the Master's degree. Additional courses are chosen from those listed above and a thesis of greater depth is required. Approximately three additional quarters are required for this program. Criteria for selection include superior academic performance, tour availability, and a demonstrated capability to perform in the environment of the professional engineer.

A limited number of academically superior students may be selected for the dual program in Naval (Mechanical) Engineering and in Management. In addition to satisfying the requirements for the degree Master of Science in Mechanical Engineering, the student will pursue a program in management leading to the degree Master of Science in Management with a specialization in either Financial Management or in Systems Acquisition Management. Management courses are taken in the following areas:

Managerial Accounting
Management Economics
Public Expenditure Policy and Analysis
Individual and Group Behavior
Personnel Management and Labor Relations
Operations Analysis
Systems Analysis
Systems Effectiveness
Systems Acquisition
Defense Project Management
Production Management
Defense Contract Administration
Logistic Support
Procurement

NAVAL INTELLIGENCE/ NATIONAL SECURITY AFFAIRS PROGRAMS CURRICULA NUMBERS 681, 682, 683, 684, 686 AND 825

THOMAS HAMMOND BARR, Commander, U.S. Navy; Curricular Officer for Naval Intelligence/National Security Affairs Programs; B.A., Stanford Univ., 1960.

WILLIAN REESE, Academic Associate for Naval Intelligence; B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

JOHN WILLIAM AMOS, Academic Associate for National Security Affairs; B.A., Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972.

NAVAL INTELLIGENCE CURRICULUM CURRICULUM NUMBER 825

OBJECTIVE — To provide advanced education in the field of Naval Intelligence. This curriculum provides a broad graduate-level education in science and engineering, national security affairs, analytical methods, and management techniques in order to further the creative application of these disciplines to the naval intelligence process. Original thinking and professional growth are emphasized by a program of study based upon the growing strategic importance of the U.S. Navy, the complex environment in which the naval intelligence officer works, and the increasing burdens upon the intelligence community. This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments and policy making positions. Naval officers develop sound graduate-level competence in national security affairs, technological aspects of naval intelligence, and analytical and management techniques. They develop a new appreciation for continuing education, acquire a diverse professional knowledge, and become aware of the many complex elements of naval, as well as national problems. They develop analytical ability for practical problem solving, broaden their capacity for original thought and discover a new personal confidence that leads to productive achievement throughout their naval career. Upon graduation, naval officers are awarded the intelligence subspecialty billet code and are eligible for the degree of Master of Arts in National Security Affairs.

More specifically, the objectives of the curriculum are to provide the students with advanced education in the following areas:

(1) the security interests of the United States and other major international actors, with particular emphasis on the military, economic, political, and social factors which shape and affect their interests and capabilities;

(2) the vocabulary, resource material, and basis of operation of military systems and subsystems which allow the incorporation of technical and environmental information into the solution of intelligence problems;

(3) an understanding of the strengths and weaknesses of current military systems (U.S. and U.S.S.R.) and areas of probable improvement within the next 10 to 15 years;

(4) methods of analysis applicable to the intelligence process, with particular emphasis upon forecasting and threat assessment;

(5) problems in the administration and dissemination of intelligence information, and the management of the intelligence process;

(6) techniques of interpersonal and group communication;

(7) In addition, students will be kept abreast of developments in naval intelligence through periodic scheduled briefings.

QUALIFICATIONS FOR ADMISSION — This curriculum is open only to officers of the U.S. Armed Forces. It affords the student an opportunity to pursue an interdisciplinary graduate program. Options available are designed to build on the various technological backgrounds of the students and permit concentration in fields of interest beyond core courses. Admission requirements are a college degree with a B average and college algebra or its equivalent. Of equal importance is demonstrated excellence in a warfare or restricted line specialty. Where an officer's fitness reports indicate consistent outstanding performance and obvious potential for promotion to senior rank, less than a B average will qualify for selection. All officers selected must be eligible for Special Intelligence access. Recipients of orders not having a

current Special Background Investigation (SBI) (within four and one half years), must submit the required request forms expeditiously in accordance with their PCS orders.

DESCRIPTION — The curriculum begins in every academic quarter of each year and lasts for 18 months. The degree awarded is Master of Arts in National Security Affairs.

The academic disciplines involved in the program include the following: political science, mathematics, management, operations analysis, oceanography, meteorology, electrical engineering, physics, computer science, and economics. The common core course of instruction reflects sponsor requirements beyond the academic degree requirements set forth in the catalogue under the Department of National Security Affairs. The sponsor requirements relate to the needs of the Naval Intelligence Community for officers prepared to fill a wide variety of assignments. These core courses requirements are divided into the four major sequences outlined below to provide the basic structure of the curriculum.

While most students progress through the core program in these sequences, flexibility is allowed to take advantage of the diverse academic background of incoming students. Those students that can validate specific core courses are permitted to concentrate in greater depth in that sequence or to choose electives from other sequences that will broaden their background in these areas. Two electives in the fifth and sixth quarters are allowed for all students. Any course which is scheduled to be taught and for which the student qualifies may be proposed as an elective. Many students select courses that relate directly to their thesis research effort to provide the opportunity for the further acquisition of skills, methodologies, and knowledge in this area. Each student's program must be approved by the Curricular Office.

The final degree and program requirement is submission of a satisfactory thesis. The purpose of the thesis is to serve as a vehicle to integrate the many disciplines in the curriculum, to demonstrate competence in original research and thinking, and to promote searching analysis of intelligence problems of interest to the students and the intelligence community. In addition, a two week TAD period allows students to discuss their research programs with interested staff officers and to locate data sources in intelligence and other government agencies.

DEFENSE TECHNOLOGY SEQUENCE

This sequence is designed to address the special problems of technical intelligence. It emphasizes technical literacy and the ability to communicate concerning technological and environmental problems with specialists at the non-mathematical level. It thus stresses vocabulary, interrelationship of concepts, and a qualitative understanding of the tradeoffs implicit in the design of military systems. While not emphasizing a quantitative approach, mathematical models are introduced where appropriate to reinforce the student's understanding of a concept and its physical application. Further, it seeks to provide a perspective that will assist assessment of the reliability and significance of technical and environmental data, as well as ensure a familiarity with available resources in these fields that may be applied to specific problems.

The sequence progresses from building technical vocabulary and qualitative understanding of basic science and engineering concepts to introduction to the general operating principles of technical military systems. Students with previous technical education may proceed directly to the applications courses. These two courses concentrate on specific military systems such as weapons, sensors, communications, and electronic warfare. The strength, weakness and trade-offs associated with ship, submarine and aircraft platform design are also included. Finally, new technological developments, weapons system acquisition and technological forecasting are pursued through student participation in seminar and practical exercise situations.

SE 2001	Environment Wave Propagations and Ocean Systems 4-0
SE 2002	Concepts of Science & Engineering I 4-0
SE 2003	Concepts of Science & Engineering II 4-0
SE 3004	Survey of Military Technology: Concepts and Applications I ..4-0
SE 3005	Survey of Military Technology: Concepts and Applications II .4-0
SE 4006	Special Topics in Technology Assessment 4-0

NATIONAL SECURITY AFFAIRS SEQUENCE

The objective of the Security Affairs Sequence

is to delineate the interface between international politics, defense resource management and weapons technology. It is this complex and multifaceted environment which impacts upon the problems to which naval intelligence must respond. Pursuant to this objective, this sequence describes and analyzes the security objectives of the major powers, assesses their capabilities, and evaluates their intentions and strategies with particular emphasis on the employment of maritime power. Further, it synthesizes the political, technological, economic, social and ideological forces that motivate the actors in the international system and models varying scenarios of interaction between them. It then relates these factors to the conduct of defense policy in the United States, the perception of specific threats, and the response of the defense establishment to them. Students with previous education in National Security Affairs may proceed directly to advanced courses.

NS 3262	Theory & Practice of International Politics	4-0
NS 3400	Problems of Government & Security in the Soviet Union	4-0
NS 3061	American National Security Policy	4-0
NS 3420	Soviet Maritime & Naval Strategy	4-0
NS 3610	Problems of Government & Security in East Asia & Pacific Ocean	5-0
NS 4161	American National Security Objectives & Net Assessment	4-0

ANALYTICAL AND MANAGEMENT SEQUENCE

This sequence introduces the student to quantitative techniques, substantive research methods, and the primary concepts of resource management. From mathematical preparatory courses it progresses to methodological survey of various means to structure given problems, formulate possible solutions, organize and compile the supporting data, assess the reliability and communicate the significance of the results obtained. The methodological courses also include study of both systems and aggregate data analysis. Management problems explored in the sequence include contracting, civilian personnel, planning/programming/budgeting (PPB), program evaluation and review techniques (PERT), management by objectives (MBO), and organizational development (OD). Also included are the management techniques applicable to automated data processing systems, their design, basic interface operations, and associated security problems. Throughout the sequence special emphasis is placed on the application of the quantitative techniques, other methodologies and substantive material assimilated to problems of current interest to naval intelligence.

MA 2310	Mathematics for Naval Intelligence I	5-3
MA 2311	Mathematics for Naval Intelligence II	5-2
OS 3510	Organizational Behavior and Naval Intelligence	4-0
NS/OS 3062	Intelligence Data Analysis	4-2
OS 3207	Operations Analysis for Naval Intelligence	4-0
NS/OS 4207	Seminar in Analysis of Intelligence Problems	4-0
NS 4063	Naval Threat Analysis	4-0
MN 3184	Management Information System for Naval Intelligence	4-0

PROFESSIONAL DEVELOPMENT SEQUENCE

The professional development sequence includes the Naval Intelligence Seminar and the Thesis Research Project. The seminar features guest speakers, field trips and study of the Naval Intelligence community and profession. The Thesis Research Project is a sponsor, as well as academic requirement. Its purpose is to provide each officer the opportunity to integrate knowledge acquired from the various disciplines in the program and apply the results to intelligence problems. Research efforts are supported directly by the intelligence community and include a research tour of up to two weeks with these agencies.

NS 0810	Thesis Research	0-0
NS 0010	Seminar in Naval Intelligence	0-2

NATIONAL SECURITY AFFAIRS CURRICULA NUMBERS 681, 682, 683 684, AND 686

OBJECTIVE: These curricula are designed to provide graduate education to DOD officers and civilians in the field of security affairs with particular emphasis on the following related areas: politico-military affairs, strategic and operational

planning, attache affairs, foreign intelligence and area analysis. These curricula may be divided into area specialties (681, 682 and 683 - delivered in cooperation with the Defense Lanaguage Institute (DLI), also in Monterey) and functional specialties (684 and 686) conducted entirely at the Postgraduate School. Successful completion of any of these curricula leads to the degree of Master of Arts in National Security Affairs.

Current program sponsors include the following: *Navy* — Deputy Chief of Naval Operations (Plans and Policy). *Air Force.*— Assistant Chief of Staff, Intelligence. *Army* — Director, Military Personnel Center, Foreign Area Office (FAO) Program.

Specific educational objectives related to these curricula are:

(1) *Geopolitics* — Students will be familiar with the geopolitical regions of the world in terms of their global strategic importance. They will understand how geography, climate, economics, and demography influence political thought and foreign policy.

(2) *Strategic Posture* - Students should know the national strengths and weaknesses which affect strategic posture and capabilities. They should be able to assess major military, political, economic, and sociological trends as they relate to policy choices in domestic and foreign affairs.

(3) *Military Forces* — Students will understand the role, political influence, social position, composition, structure, capabilities, and vulnerabilities of the armed forces. They should be familiar with current political and military developments. They should be familiar with regional military and political relations and regional defense agreements both bilateral and multilateral.

(4) *Geography* — Students should have knowledge of geography and its influence on national development, domestic transportation, economic and military posture. Area specialists should have a more detailed geographical knowledge of their areas and the strategic significance of their specific regions.

(5) *Economics* - Students must be aware of the economic strengths and weaknesses of the major power blocs of the world, as well as economic phenomena which influence ideology, military doctrine, industrial and social development. Area Specialists must be familiar with their respective region's principal resources and economic influence in the world, as well as their region's industrial capacity and principal industries.

(6) *Politics* - Students should have a knowledge of the major types of political systems and governmental organizations. They should be aware of current political doctrine and issues. They should know the strength, appeal and influence of Communism and other ideologies. Area specialists should have a more detailed knowledge of their area and be aware of the current relationships and attitudes toward both the United States and the Soviet Union prevalent in it.

(7) *Culture and Religion* - The student should be familiar with the influence of class structure, cultural and religious values, and ideology on domestic and foreign affairs. They should understand the origins and present state of cultural and religious differences and conflicts and how these differences affect regional and national cohesiveness.

(8) *Current Issues* - Students must be familiar with the major security issues in the world today. These include, but are not limited to political and military conflicts, insurgencies, social problems and efforts for social reform, economic problems and other issues which affect both the status or well-being of the nations of the world. Knowledge of these issues should be related to the formulation and implementation of U.S. foreign and security policy.

(9) *Analytical and Research Skills* - Scholarly skills emphasized throughout the program include: effective oral and written expression, techniques of research, interpretation and evaluation of complex data, problem solving, forecasting, decision making, the process of negotiation and debate, the formulation of strategy and politico-military objectives.

QUALIFICATIONS FOR ADMISSION — These curricula are open to officers and civilians of the Department of Defense. The entrance requirements for these programs are a baccalaureate degree earned with above average academic performance. Applicants may demonstrate their aptitude for the specific curriculum concerned through undergraduate courses that meet program prerequisites, Graduate Record Examination results, or other evidences. Applicants must have the approval of the Chairman, Department of National Security Affairs.

AREA SPECIALTY CURRICULA

#681 - Middle East, Africa, South Asia
#682 - Far East, Southeast Asia, Pacific
#683 - Europe, USSR

DESCRIPTION: These curricula are cooperative programs with the Defense Language Insti-

tute. They last from one to two years depending upon the curricula and option selected, the language studied, and previous educational background. Inputs can be accepted to these programs each quarter of the academic year (July, September, January or March). Officers are assigned to NPS for the full duration of the combined program. Quotas for the language instruction are obtained directly from DLI by the Curricular Office, except in the case of those students who have acquired language proficiency either at DLI or other institutions prior to their admission to the program. Finally, for those sponsors whose students do not require language instruction, a purely academic option conducted completely at NPS is offered.

Student programs are developed from the courses outlined below. Primarily they are comprised of a common core consisting of at least six functionally-oriented security affairs courses, at least nine area oriented security affairs courses, and either a comprehensive examination or a thesis research project. The selection of specific courses is based on the area specialty and sponsor requirements concerned. Course mix and sequence will also vary according to the quarter of entry into the program.

Common Core

NS 3061 American National Security Policy 4-0
NS 3078 The Politics of National and Global Economic Relations 4-0
NS 3169 Comparative Political Analysis and Research Methods 4-0
NS 3262 Theory and Practice of International Politics 4-0
NS 4140 Problems of Security Assistance and Arms Transfers 4-0
NS 4273 American Foreign Policy and World Politics 4-0
NS 4000 Perspectives on American Civilization 4-0
NS 0810 Thesis Research 0-0
NS 0811 Preparation for Comprehensive Examination 0-0

#681 - Middle East, Africa, South Asia

NS 3300 Problems in Government and Security in the Middle East 4-0
NS 3310 North Africa: Government and Security in the Maghreb 4-0
NS 3312 Seminar in Middle East Oil 4-0
NS 3313 Problems in Government and Security in Sub-Saharan Africa 4-0
NS 3314 Problems of Government and Security in Israel 4-0
NS 3315 Middle East: The Military Dimension 4-0
NS 3316 Problems of Government and Security in the Northern Tier: Turkey, Iran, Afghanistan and Pakistan 4-0
NS 3320 International Relations and Security Problems of the Middle East 4-0
NS 3330 Military Geography and History of the Middle East 4-0
NS 3331 20th Century Middle Eastern Military and Political History 4-0
NS 3350 Area Colloquium in Middle Eastern Studies I 2-0
NS 3351 Area Colloquium in Middle Eastern Studies II 2-0
NS 3620 Problems of Government and Security in South Asia and the Indian Ocean 4-0
NS 3710 International Security Problems of the Mediterranean 4-0
NS 4300 Seminar in Security Problems of the Middle East 4-0
NS 4330 Seminar in Middle Eastern Civilizations 4-0

#682 - Far East, Southeast Asia, Pacific

NS 3400 Domestic Determinants of Soviet National Security Policy 4-0
NS 3410 Soviet National Security and Foreign Policy Making Processes 4-0

NS 3440 Comparative Communist Political Systems 4-0
NS 3605 Geography, History and Culture of Asia 4-0
NS 3606 Problems of Government and Security in Penninsular Southeast Asia 4-0
NS 3608 Problems of Government and Security in Insular Southeast Asia 4-0
NS 3610 Problems of Government and Security in East Asia and the Pacific Ocean 5-0
NS 3611 Problems of Government and Security in Contemporary Japan 4-0
NS 3612 Problems of Government and Security in the Peoples Republic of China 4-0
NS 3620 Problems of Government and Security in South Asia and the Indian Ocean 4-0
NS 3650 Area Colloquium in Asian Studies I 2-0
NS 3651 Area Colloquium in Asian Studies II 2-0
NS 4630 International Security Problems of Asia and the Adjacent Oceans 4-0
NS 4710 Seminar in Sino-Soviet Relations 4-0

#683 - Europe, USSR

NS 3268 Problems of Government and Security in Europe 4-0
NS 3280 Nuclear Weapons and Foreign Policy 4-0
NS 3400 Domestic Determinants of Soviet National Security Policy 4-0
NS 3410 Soviet National Security and Foreign Policy Making Process 4-0
NS 3420 Soviet Naval and Maritime Strategy 4-0
NS 3430 Soviet Military Strategy 4-0
NS 3440 Comparative Communist Political Systems 4-0
NS 3450 Area Colloquium in Soviet Studies I 2-0
NS 3451 Area Colloquium in Soviet Studies II 2-0
NS 3610 Problems of Government and Security in East Asia and the Pacific 5-0
NS 3700 Strategic Geography and History of Europe 4-0
NS 3701 Recent History of Europe and USSR 4-0
NS 3710 International Security Problems of the Mediterranean 4-0
NS 3750 Area Colloquium in European Studies I 2-0
NS 3751 Area Colloquium in European Studies II 2-0
NS 3800 Problems of Government and Security of the Scandinavian-Baltic Region 4-0
NS 4400 Seminar in Soviet Security Problems 4-0
NS 4425 Advanced Topics in Soviet Naval Affairs 4-0
NS 4700 Seminar in Soviet and European Affairs 4-0
NS 4701 Seminar in Political and Security Problems of Europe 4-0
NS 4710 Seminar in Sino-Soviet Relations 4-0

FUNCTIONAL SPECIALTY CURRICULA

#684 - International Organizations and Negotiations
#686 - Strategic Planning

DESCRIPTION: These curricula last up to 18 months. Entry may be made any academic quarter (July, September, January, March). These curricula emphasize functional studies applicable to security affairs. Area study courses are also featured, but normally they apply to all, vice one specific region. Program mix and sequence is selected from the courses outlined below according to quarter of entry into the program and the sponsor requirements concerned.

Functional Specialty Courses:

NS 3032 Revolution and Political Terrorism in the Modern World 4-0

NS 3061 American National Security Policy 4-0
NS 3078 The Politics of National and Global Economic Relations 4-0
NS 3164 Comparative Ideology 4-0
NS 3169 Comparative Political Analysis and Research Methods 4-0
NS 3172 Public Policy Processes 4-0
NS 3262 Theory and Practice of International Politics 4-0
NS 3275 International Law 4-0
NS 3276 Law of War 4-0
NS 3280 Nuclear Weapons and Foreign Policy 4-0
NS 3900 International Organization 4-0
NS 3901 Ocean Policy 4-0
NS 3902 Science, Technology and Public Policy 4-0
NS 4061 Survey of Strategic Studies 4-0
NS 4077 Strategic Resources and U.S. National Security Policy 4-0
NS 4140 Problems of Security Assistance and Arms Transfers 4-0
NS 4161 American National Security Objectives and Net Assessment 4-0
NS 4273 American Foreign Policy and World Politics 4-0
NS 0810 Thesis Research 4-0
AS 3510 Organizational Behavior and Naval Intelligence 4-0

Area Study Courses:

NS 3268 Problems of Government and Security in Europe 4-0
NS 3320 International Relations and Security Problems in the Middle East 4-0
NS 3400 Domestic Determinants of Soviet National Security Policy 4-0
NS 3410 Soviet National Security and Foreign Policy Making Process 4-0
NS 3420 Soviet Naval and Maritime Strategy 4-0
NS 3430 Soviet Military Strategy 4-0
NS 3520 Problems of Diplomacy and Security in Latin America 4-0
NS 3610 Problems of Government and Security in East Asia and the Pacific 5-0
NS 3620 Problems of Government and Security in South Asia and the Indian Ocean 4-0
NS 3701 Recent History of Europe and the USSR 4-0
NS 3710 International Security Problems of the Mediterranean 4-0
NS 4300 Seminar in Middle East Security Problems 4-0
NS 4630 Seminar in Asian Security Problems 4-0
NS 4700 Seminar in Soviet-European Relations 4-0
NS 4710 Seminar in Sino-Soviet Relations 4-0

Additional information on any of these curricula (681, 682, 683, 684, 686, and 825) may be addressed to the Curricular Officer, Naval Intelligence/National Security Affairs Programs (Code 38), Naval Postgraduate School, Monterey, CA 93940. Telephone (408) 646-2228 or AUTOVON 878-2228.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS PROGRAM CURRICULUM NUMBER 360

JOSEPH HENRY CYR, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S. Purdue Univ., 1960; M.S., Naval Postgraduate School, 1969.

BRIAN DAVID ENGLER, Lieutenant, U.S. Navy; Assistant Curricular Officer; B.S., U.S. Naval Academy, 1969; Naval Postgraduate School, 1970.

JAMES KERN HARTMAN, Academic Associate; B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM CURRICULUM NUMBER 360 (GROUP RO)

OBJECTIVE — To develop judgment and professional expertise in the quantitative analysis of military operational and defense managerial problems ashore and afloat. The disciplines of mathematics, probability, statistics, economics, human factors, physical science, and optimization supply the theoretical background for analyzing alternative choices in tactical and strategic warfare and in planning, budgeting and procurement of systems and forces. Skills in finding relevant information, generating decision criteria, and selecting alternatives are developed as well as computational capability.

This program provides the officer with a sound graduate-level technical ability, insight into practical problem solving, a broadened capacity for original thought, and an appreciation for the value of continuing education; these qualities generate a strong personal confidence which will enhance performance of duty and lead to productive achievement throughout the officer's military career.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with above-average grades in mathematics is required. Completion of mathematics through calculus is considered minimal preparation. A one year course in college physics is highly desired (Supply Officers excluded). Students lacking these quantitative prerequisites will be accepted, in certain cases, where their under-graduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative subjects, and outstanding motivation for the program.

DESCRIPTION — The Operations Research/Systems Analysis programs is interdisciplinary in nature, consisting of course work in operations research, probability and statistics, mathematics, physical science, economics, human engineering, and computer science. Classes convene semiannually, in March and September. As the typical officer student is returning to a formal academic program after 6 or 7 years (average) of operational military duty, and because the needs of the military services frequently require that the officer's graduate work lie in a field different from his undergraduate major, the program includes a certain amount of introductory material which must precede advanced study in this field.

The advanced study phase of the program will normally require four to five academic quarters to complete. The introductory phase of the program will vary in length from one to four academic quarters, depending upon the student's background and academic preparation. Credits transferred from other institutions may be applied to graduate degree requirements. Validation of courses is highly encouraged.

Near the end of the introductory phase of the program, officers are screened for admission to the master's candidacy. Those officers admitted to the Master's candidacy elect an option course se-

quence and must submit an acceptable thesis in order to qualify for the degree Master of Science in Operations Research.

An integral part of the advanced phase of the program is a six-week experience tour in which the officers are assigned as working members of appropriate military or industrial groups engaged in operations research/systems analysis on military problems. The experience tour is designed to permit the student to become involved in the practical application of military operations research and to identify problems of real military interest which the officer may pursue as part of his advanced study and thesis effort.

An important adjunct to the formal classroom work is the seminar series, OA 0001 (0-2), in which guest lecturers present first-hand information as to practical principles and techniques in the field of Operations Research/Systems Analysis. This seminar is scheduled for every Operations Research/Systems Analysis student in every quarter.

Upon successful completion of the program, the naval officer is awarded an appropriate subspecialty billet code.

A few exceptionally well-qualified officers are selected for doctoral studies each year, depending upon the needs of the military services.

Introductory Study

The introductory study portion of the Operations Research/Systems Analysis program provides necessary background and tool subjects for successful pursuit of the graduate study. This portion of the program is of variable length depending on the amount of the course work listed below which can be validated by examination or credited from a prior academic transcript. Descriptions of the courses appear in the departmental listings of this catalogue. A nominal course load is 16 credit hours during any academic quarter. Prior to beginning the program a review of elementary calculus, elementary physics and computer programming, through correspondence or extension courses, is strongly urged.

Mathematics

MA 2109	Topics in Calculus	5-0
MA 2110	Multivariable Calculus	4-0
MA 2042	Linear Algebra	4-0

Probability & Statistics

PS 2301	Probability	4-0
PS 3302	Probability and Statistics	4-1
PS 3303	Statistics	4-1

Physical Science

PH 3321	Radiation Systems	4-0

Economics

AS 3609	Introduction to Mathematical Economics	4-0
AS 3610	Utility Theory and Resource Allocation	4-0

Operations Analysis

OA 2600	History and Nature of Operations Analysis	2-0
CS 2600	Introductory Computing and Computer Science for Operations Analysis	2-0
OA 3604	Linear Programming	4-0
OA 3653	System Simulation	4-0
OA 3657	Human Factors in System Design	4-0

Graduate Study

The graduate program consists of required courses, elective courses, option courses, experience tour, and thesis research. Any transfer of graduate credit which is applicable may be used to reduce the number of courses taken in the program.

Core Courses

AS 3611	Systems Analysis I	4-0
OA 3200	Computational Methods in O.R.	3-2
OA 3654	War Gaming	3-2
OA 3660	Analysis of Operational Data	3-1
OA 3704	Stochastic Models I	4-0

OA 4631	Nonlinear and Dynamic Programming	4-0
OA 4651	Search Theory and Detection (USN Line)	4-0
OA 4705	Stochastic Models II	3-2

Elective Courses – The program permits selection of one elective course in the student's thesis subject area.

EXPERIENCE TOUR — Eight quarter hours are allocated for the experience tour which is usually taken in the last six weeks of the first quarter of advanced study.

THESIS RESEARCH — Twelve quarter hours are allocated for thesis research, four each in the student's final three quarters of the program.

OPTION COURSES — Five courses chosen from a particular option area are required. The options offer a degree of specialization in a particular area in recognition of requirements of the officer's military service or corps. The selection of these courses is developed in consultation with a faculty option advisor from the following areas:

Operations Evaluation (Navy) Option – Preparation for dealing with the analysis of tactics and hardware in Naval Warfare.

OA 4322	Sample Inspection and Quality Assurance	4-0
OA 4617	Campaign Analysis	4-0
OA 4633	Network Flows and Graphs	4-0
OA 4652	OR Problems in Naval Warfare	3-0
OA 4653	Operational Test and Evaluation	3-2
OA 4662	Reliability and Weapon System Effectiveness Measurement	4-0
OA 4685	Skilled Operator Performance	3-2
OC 4260	Sound in the Ocean	3-0
PS 4321	Design of Experiments	3-1

Operations Evaluation (Marine Corps, Army) Option – Preparation for dealing with the analysis of land combat operations.

OA 4614	Cost Estimation	4-0
OA 4617	Campaign Analysis	4-0
OA 4634	Games of Strategy	4-0
OA 4653	Operational Test and Evaluation	3-2
OA 4654	Combat Models	4-0
OA 4655	Quantitative Analysis of Tactics	4-0
OA 4656	Operations Research of Army Weapons Systems	4-0
OA 4662	Reliability and Weapons System Effectiveness Measurement	4-0
PS 4321	Design of Experiments	3-1

Systems Analysis Option – Preparation for dealing with defense department resource allocation, planning, and programming.

AS 4613	Theory of Systems Analysis	4-0
OA 4614	Cost Estimation	4-0
OA 4615	Econometrics	4-0
OA 4616	Defense Expenditure and Policy Analysis	4-0
OA 4617	Campaign Analysis	4-0
OA 4653	Operational Test and Evaluation	3-2
MN 4942	Structure, Conduct, and Performance of the Defense Industries	4-0

Human Factors Option – Preparation for dealing with human performance evaluation and the design of man/machine systems.

OA 3658	Human Factors in Systems Design II	3-0
OA 4322	Sample Inspection and Quality Assurance	4-0
OA 4323	Decision Theory	3-0
OA 4680	Human Performance Evaluation	4-0
OA 4685	Skilled Operator Performance	3-2
OA 4690	Evaluation of Human Factors Data	3-2
OA 4695	OR in Man/Machine Systems	4-0
PS 4321	Design of Experiments	3-1

Logistics Option – Preparation for dealing with supply systems for Navy Supply Corps and Quartermaster or Maintenance officers.

OA 3620	Inventory I	4-0
OA 4615	Econometrics	4-0
OA 4621	Inventory II	4-0
QA 4633	Network Flows and Graphs	4-0

MN 2150	Financial Accounting	4-0
MN 3161	Managerial Accounting	4-0
MN 3371	Military Procurement and Contract Administration	4-0
MN 4181	Applications of Management Information Systems	4-0
MN 4372	Physical Distribution in Supply Systems	4-0
PS 4440	Time Series Analysis	4-0

Advanced Modelling Option – Preparation for dealing with the theory and techniques of operations research.

OA 3620	Inventory I	4-0
OA 4632	Mathematical Programming	4-0
OA 4633	Network Flows and Graphs	4-0
OA 4634	Games of Strategy	4-0
OA 4662	Reliability and Weapons Systems Effectiveness Measurement	4-0
OA 4706	Stochastic Models III	4-0
PS 3421	Nonparametric Statistics	4-0

WEAPONS ENGINEERING PROGRAMS CURRICULA NUMBERS 530, 531 AND 535

EDWARD JOSEPH MAHON, Commander, U.S. Navy; Curricular Officer, Weapons Engineering Programs; B.S., U.S. Naval Academy, 1957; B.S., Naval Postgraduate School, 1967.

ROBERT CECIL WILLEMS, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer, Underwater Acoustics Program; B.S., Fort Hays Kansas State College, 1965; M.S., Naval Postgraduate School, 1972.

JOHN NORVELL DYER, Academic Associate; B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

Several curricular programs are administered by the Weapons Engineering Curricular Office as follows:

530	Weapon Systems Technology
531	Weapon Systems Science
535	Underwater Acoustics

OBJECTIVES — To provide graduate education to officers from all communities in the fundamentals of certain engineering, scientific and analytical principles with which to increase their ability to analyze, understand, and manage the complex naval weapon systems in the environments in which they operate; to enhance operational and command competence of naval weapon systems in the environments in which they operate; to enhance operational and command competence of naval officers in various warfare subspecialties; to provide the professional expertise, technical competence and practical experience to develop the ability to relate fundamental concepts directly to naval weapon systems; to build a new appreciation for continuing education; to broaden their capacity for original thought, and to enhance their discovery of a new personal confidence leading to productive achievement throughout their naval career.

This education enhances performance in all duties throughout a naval career including operational billets, technical management assignments, and policy making positions, thereby preparing the officer for increased responsibility, including command, both ashore and afloat.

QUALIFICATIONS FOR ADMISSION — A baccalaureate degree with mathematics through differential and integral calculus is required. Courses in the physical sciences and engineering are desirable.

Allied officers may enroll in the above curricula subject to the exclusion of classified courses as determined by the Chief of Naval Operations.

DESCRIPTION — The structure of each curriculum takes into account the fact that the typical officer student has been away from an academic environment for some time and is not usually prepared to engage in graduate studies without some preparation. The extent of the preparation will depend upon the academic background of the individual officer and will be decided upon by the officer student in consultation with his Curricular Officer and Academic Associate. Officers with less technical background than is considered sufficient for direct entry into one of the programs described here may be first enrolled in the Engineering Science curriculum for one or more quarters for additional preparation.

The Continuing Education Program was established at the Naval Postgraduate School in June 1974 as a means of providing extended educational services. The self-instructional courses can be delivered to officers at their current duty stations for completion during off-duty hours or work/study periods. These have been selected primarily from courses normally taken in the initial phase of curricular programs at the Naval Postgraduate School and will serve to provide general

educational upgrading opportunities. More particularly, their completion can reduce student time required in subsequent fully-funded graduate education programs.

The curricula described below are interdisciplinary in nature because of the wide knowledge required of the graduate. Each curriculum consists of a number of basic courses designed to provide a smooth transition from previous studies. In a typical program, most of the first four or five quarters are devoted to the basic "core" material. Portions of this undergraduate preparation may be validated by an academically prepared officer to permit study to greater depth or breadth in graduate electives, or subject to course scheduling limitations, to shorten his time on board. The remainder of the program is dedicated to advanced graduate specialization and elective choices. Upon successful completion of an approved curriculum, officers will be awarded an appropriate subspecialty billet code. Officers should refer to the Annual Naval Officer Billet Summary for possible assignment wherein they could apply their recently acquired education. Students will be awarded the degree of Master of Science in an appropriate discipline dependent upon academic achievement and successful completion of required courses. On-going counseling is provided by the Curricular Officer/Academic Associate team for all students and a close professional relationship between officer students and faculty enables each officer to make his time at the School a valuable asset to his professional development and career.

Descriptions of each curriculum and typical programs follow. Specific degree requirements may be found under the appropriate departmental section of the catalogue.

WEAPON SYSTEMS ENGINEERING

Graduate education in weaponry and ordnance systems has long been one of the primary functions of the Naval Postgraduate School. As weapons have developed and become more complex, education at NPS has also changed to keep pace with rapidly emerging technology upon which combat systems are developed. Today and tomorrow all professional military leaders must understand those principles and technologies if they are optimally to operate, manage and command combat systems for which they will be responsible.

Education in Weapon Systems Engineering must include extensive breadth as well as specialization at the graduate level. Combat systems are complex and dependent upon a wide range of basic scientific knowledge in areas such as explosives and propellants, plasmas, materials science, controls, electronics, electro-optics, lasers, radars, communications and signal processing, and nuclear science. Depth at the graduate level in one or more of these areas is required of each student involved in Weapon Systems Engineering. In addition, each program addresses systems aspects of reliability, testing, effectiveness and procurement.

WEAPON SYSTEMS TECHNOLOGY CURRICULUM 530

DESCRIPTION — This is a program designed to meet the needs of the military services for an officer whose broad-based technical education emphasizes the concepts of systems engineering. Applications of classroom theory to current weapon systems, and those under development, are stressed throughout the curriculum. This curriculum includes graduate level studies of computer science and real-time computer systems, electrical engineering with emphasis on control systems, technology of explosives and propellants, material science with emphasis on mechanical behavior and failure modes of materials. Also included are methodology and techniques of systems engineering, and two in-depth option sequences wherein students may specialize in particular technical subjects of current service needs. These electives permit students to broaden their knowledge of weapon systems and also to reach greater depth in some particular area. Students also engage in thesis research in an area related to these advanced studies. Graduates are awarded the degree Master of Science in Applied Science.

A recently incorporated option in this curriculum will allow some officers to pursue ad-

vanced studies in electrical engineering and to earn the degree Master of Science in Electrical Engineering. This option has replaced the previously offered Engineering Electronics (Weapons) curriculum 532.

In view of the wide breadth of the 530 curriculum that addresses all aspects of weaponry, successful graduates, regardless of option, will receive the Weapon Systems Technology subspecialty code XX61.

In addition to the formal course work and laboratories, students will participate in and report on projects designed to investigate components of major weapon systems in order to exercise their experience and their education to consider the "real-life" aspects of systems engineering.

A guest lecture and seminar program, plus quarterly visits to West Coast weapon-related activities, serve to keep students informed of current developments and stress the present day utilization of theory and technology.

Introductory and Core Studies

This portion of the program provides the basic mathematical, scientific and engineering courses, along with an introduction to systems engineering required for successful pursuit of the graduate electives, as well as those graduate studies required of all students. Each student's transcript will be evaluated for validation of as many of the introductory courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

The core courses, including some undergraduate level studies, typically contain the following:

Calculus, matrix algebra, vector analysis, complex numbers
Ordinary and partial differential equations
Mathematical series and transforms
Electromagnetic wave theory and propagation
Thermodynamics and physical chemistry of propellants/explosives
Systems engineering for weapon systems
Weapon systems testing and reliability
Technology and damage potential of explosives
Engineering materials and structural failures of weapon systems
Computer modeling and programming
Real-time military computer systems
Electrical engineering, linear systems, control of weapon systems
Military communications systems

Graduate Specialization

For the officer pursuing the general Weapon Systems Technology program, a number of graduate options are available. Some typical areas for advanced study are:

Signal processing applied to weapon systems
Military radars and electronic countermeasure systems
Advanced control theory of weapon systems
Electro-optics and laser technology
Nuclear physics and radiation effects
Advanced engineering mechanics and analyses of weapon systems
Operations research/system analysis associated with military systems
Advanced military communications theory
Computers for command, control, and weapon systems

For the officer who is to pursue his graduate studies in the field of electrical engineering, the areas of advanced study will typically include the following:

Microwave devices
Discrete signal processing
Statistical communication theory
Advanced radar systems
Advanced systems engineering
Advanced control theory
Antenna engineering

This curriculum commences annually each September. March input by request.

WEAPON SYSTEMS SCIENCE CURRICULUM #531

DESCRIPTION — This is a program which has evolved from what was previously the Electro-optics/Laser Technology option of the Weapon Systems Engineering program. It is designed to meet the needs of the military services for graduates who have a strong background in technical and engineering physics, coupled with an appreciation of the concepts of systems engineering, especially as they relate to weapons. This core curriculum includes studies in electromagnetic wave propagation and communications, real-time computer systems, the chemistry of explosives and propellants, particle and fluid mechanics, signal

processing, reliability and maintainability of weapon systems, and a thorough sequence of courses in atomic and molecular phenomena. Graduate options are available in specialized areas such as electro-optics and laser technology, nuclear science, plasma physics or other areas depending upon current service needs.

In order to keep students informed of current developments and present-day utilization of theory and technology, the program includes an active guest lecture and seminar series. Also, the students participate in quarterly visits to various West Coast military activities.

In addition to formal course work, students participate in group projects in which components of major weapon systems are investigated. This encourages them to combine their operational experience with their education in considering "real-life" aspects of systems engineering.

After completion of core curriculum, graduate level courses continue in two option sequences. In the first of these, studies emphasize and broaden the student's knowledge of weapon systems. In the second, advanced scientific studies and thesis research are pursued which qualify the student for the subspecialty code XX63 (Physics) with specialization in an area of current service needs.

Introductory and Core Studies

This portion of the program provides the basic mathematical and engineering physics background, along with an introduction to systems engineering, required for successful pursuit of the graduate options. It also contains those graduate studies required of all students in the program. Each student's academic transcript will be evaluated for validation of as many of the introductory courses as possible. The remaining courses will be programmed with a normal load of four courses each quarter.

The core courses, including some undergraduate level studies, typically contain the following:

Calculus, matrix algebra, vector analysis, complex numbers
Ordinary and partial differential equations
Mathematical series and transforms
Electromagnetic propagation/communications
Thermodynamics and statistical physics
Weapon systems integration and engineering
Military systems reliability and maintainability
Particle and fluid mechanics
Chemistry of ordnance
systems/explosives/propellants
Real-time military computers/signal processing
Modern physics/quantum phenomena

Graduate Specialization

In the scientific graduate sequence leading to qualification for the subspecialty XX63, some typical specializations are:

Electro-optics/military applications and devices
Laser and laser effects/laser damage
Plasma physics/laser energy absorption
Fluid drag reduction/vehicle hydrodynamics
Nuclear physics and radiation effects
Physics of the ocean-air interface
Space and missile dynamics/atmospheric physics

In the graduate sequence dealing with the broader aspects of Weapon Systems Engineering, courses in the following areas are typical:

Weapon control systems
Advanced military radar systems
Electronic warfare systems
Operations research/military systems analysis
Explosives technology/propellants/blast effects
Computer systems/military applications
Environmental effects on military systems

This curriculum commences annually each March. September input by request.

UNDERWATER ACOUSTICS CURRICULUM #535

DESCRIPTION — Underwater Acoustics is an interdisciplinary program. At NPS, courses of study are taken in physics, electrical engineering, oceanography and mathematics. Specific coverage is provided in such areas as propagation of sound in the sea, transducer theory, signal processing electronics, oceanography, and noise and vibration control. Successful completion of the curriculum permits the graduate to address current and future military problems associated with underwater acoustics systems and to expand his base of professional knowledge and technical competence.

Courses are drawn principally from the fields of physics, electrical engineering, oceanography and mathematics. Although broadly based, the emphasis is on underwater acoustics and its applications to Undersea Warfare. As can be seen in the follow-

ing list, courses included relate to the generation and propagation of sound in the ocean, military applications of underwater sound and the electrical engineering of instruments for the detection of underwater sounds. Also included are topics concerning the effects of the noise environment on people.

As an integral part of his program, each officer prepares a thesis under the guidance of a faculty member.

In addition, the program includes short field trips, visits to facilities working on current military acoustic problems, and participation in such meetings as the Navy Symposium on Underwater Acoustics.

Within the Navy, successful completion leads to an approved subspecialty code of XX56 and thus qualifies the graduate officer for assignments to challenging subspecialty billets throughout the military establishment.

Introductory Study

This portion of the program provides the necessary mathematics, electrical engineering, and physics required for successful pursuit of the graduate curriculum. Each student's transcript will be evaluated for validation of as much material as possible. The remaining studies will be scheduled with a normal load of four courses each quarter.

Calculus review
Linear algebra
Differential equations
Mathematical physics
Numerical methods
Review of vector mechanics and fluids
Thermal and dynamic properties of gases and liquids
Basic circuit theory
Circuit analysis
Communication theory
Electronic engineering fundamentals
Digital machines
Oceanography

Graduate Study

The graduate portion of the program includes courses in the following areas:

Partial differential equations and integral transforms
Applied probability
Electromagnetic wave propagation
Physics of underwater vehicles
Fundamental acoustics
Underwater acoustics
Propagation of waves in fluids
Transducer theory and design
Advanced acoustics laboratory
Seminar in applications of underwater sound
Mechanical waves in solids
Shock, vibration and noise control in military systems
Shock waves and nonlinear acoustics
Sonar systems engineering
Acoustic signal processing
Oceanographic factors in underwater sound

This curriculum commences annually each September.

CURRICULA CONDUCTED AT OTHER UNIVERSITIES

PETER KENNETH STEVENSON, Commander, U.S. Navy; Manager, Graduate Education at Civilian Institutions; B.S. in Engineering Science, Naval Postgraduate School, 1970; M.S. in Management, 1971.

Curriculum	*Number*	*Length*	*Institution*	*Primary Consultant*
Advanced Science (Math)	380	2 yrs	Various	OP-96
Advanced Science (Chem)	382	2 yrs	Various	NAVSEASYSCOM
Supply Aquisition/Distrib	810	12-18 mos	Various	NAVSUPSYSCOM
Criminal Law	884	1 yr	Various	JAG
Facilities Engineering	47X	1-2 yrs	Various	NAVFACENGCOM
Forensic Science	885	1 yr	Armed Forces Institute of Pathology*	JAG
International Law	672	1 yr	George Washington Univ*	JAG
Joint/Strategic Intell	990	9 mos	Defense Intell School*	NAVINTCOM
Labor Law	886	1 yr	Various	JAG
Law (Army Judge Advocate Officers Adv. Course)	881	9 mos	U. of Virginia	JAG
Logistics Management	700	1 yr	Air Force Institute of Technology*	CHNAVMAT
Naval Constr & Engrg	510	2-3 yrs	M.I.T.	NAVSEASYSCOM
Nuclear Effects (Phys)	521	18 mos	Air Force Institute of Technology*	NAVSEASYSCOM
Nuclear Engineering (CEC)	572	18 mos	Penn State Univ.	NAVFACENGCOM
Nuclear Engineering (ED)	520	18 mos	Penn State Univ	NAVSEASYSCOM
Ocean Engineering	472	1-2 yrs	Various	NAVFACENGCOM
Ocean Law	883	1 yr	Various	JAG
Petroleum Admin & Mgmt	880	1 yr	Various	JAG
Petroleum Engineering	630	1-2 yrs	U. of Texas	NAVFACENGCOM
Petroleum Management	811	17 mos	U. of Kansas	NAVSUPSYSCOM
Pol-Mil (Western Hemisphere)	685	1 yr	Various	CNO
Public Affairs	920	1 yr	American Univ*	CHINFO
Religion	970	9 mos	Various	CHCHAP
Retailing	830	1 yr	Michigan State*	NAVSUPSYSCOM
Subsistence Technology	860	1 yr	Michigan State*	NAVSUPSYSCOM
Taxation	882	1 yr	Various	JAG

**No NROTC Unit at Institution*

DEPARTMENT OF ADMINISTRATIVE SCIENCES

CARL RUSSELL JONES, Professor of Administrative Sciences; Chairman (1965)*; B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

JAMES KENICHI ARIMA, Associate Professor Operations Research and Behavioral Science (1969); B.A., Univ. of California at Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

JAMES DAVID BUTTINGER, Lieutenant Commander, U.S. Navy; Instructor in Economics/Systems Analysis (1975); B.S., U.S. Naval Academy, 1967; M.S., Naval Postgraduate School, 1971.

PAUL MARSHALL CARRICK, Associate Professor of Management (1969); B.A., Northwestern Univ., 1949; Ph.D., Univ. of California at Berkeley, 1956.

WILLIAM HOWARD CHURCH, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

JOHN WALLIS CREIGHTON, Professor of Management (1967); B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

ALEXANDER CLAYTON CROSBY, Commander, U.S. Navy; Instructor in Management (1975); B.S., Univ. of California at Berkeley, 1957; M.B.A., Harvard Univ., 1972.

LESLIE DARBYSHIRE, Professor of Management (1962); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

STANLEY MICHAEL DEAN, Associate Professor of Management (1973); B.A., Brigham Young Univ., 1962; M.B.A., Harvard Univ., 1964; D.B.A., 1974.

CLYDE BROOKLYN DERR, Associate Professor of Management (1974); B.A., Univ. of California at Berkeley, 1967; Ed.D., Harvard Univ., 1971.

RICHARD SANFORD ELSTER, Associate Professor of Management and Psychology (1969); B.A., Univ. of Minnesota, 1963; M.A., 1965; Ph.D., 1967.

CARSON KAN EOYANG, Associate Professor of Management (1974); B.A., Massachusetts Institute of Technology, 1966; M.B.A., Harvard Univ., 1968; Ph.D., Stanford Univ., 1976.

RAYMOND LLOYD FORBES, JR., Lieutenant Commander, U.S. Navy; Assistant Professor of Administrative Sciences (1976); B.S., U.S. Naval Academy, 1959; M.A., United States International Univ., 1971; Ph.D., 1973.

JAMES MORGAN FREMGEN, Professor of Accounting (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

WILLIAM CANNONG GIAUQUE, Associate Professor of Administrative Sciences (1973); B.S., California Institute of Technology, 1963; M.B.A., Harvard Univ., 1968; D.B.A., 1972.

CHARLES BENGT GUSTAFSON, Commander, U.S. Navy; Instructor in Administrative Sciences (1977); B. Arch., Miami Univ., 1957; M.S. in Management, Naval Postgraduate School, 1971.

WILLIAM JAMES HAGA, Associate Professor of Management Sociology (1972); B.B.A., Wayne State Univ., 1960; M.A., Univ. of Illinois, 1970; Ph.D., 1972.

FENN CLARK HORTON, Associate Professor of Economics (1964); B.A.,

State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., 1968.

JERRY DOUGLAS HORTON, Commander, U.S. Navy; Instructor in Management (1976); B.S., U.S. Merchant Marine Academy, 1957; M.S., Naval Postgraduate School, 1966.

ROBERT RUSSELL JUDSON, Adjunct Professor of Management (1973); B.A., Univ. of Illinois, 1951; M.S., 1955.

MELVIN BERNARD KLINE, Professor of Management (1970); B.S., College of the City of New York, 1941; M.S., Stevens Institute of Technology, 1952; M.E., Univ. of California at Los Angeles, 1959; Ph.D., 1966.

RICHARD ALLIN McGONIGAL, Commander, U.S. Navy; Assistant Professor of Management (1974); B.S., Cornell Univ., 1951; B.D., Union Theological Seminary, 1954; S.T.M., Columbia Univ., 1966; Ph.D., Michigan State Univ., 1971.

ALAN WAYNE McMASTERS, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

NEIL PATRICK MILLER, Lieutenant Colonel, U.S. Marine Corps; Instructor in Administrative Sciences and Computer Science (1976); B.A., Univ. of California at Berkeley, 1956; B.A., Southern Colorado State College, 1965; M.S., Management/Data Processing, Naval Postgraduate School, 1966.

JOSEPH FREDERICK OWENS, Lieutenant Commander, Supply Corps, U.S. Navy; Instructor in Management (1976); B.A., Grinnell College, 1961; M.B.A., Columbia Univ., 1962.

KENNETH LEON PATTERSON, Lieutenant Commander, U.S. Navy; Instructor in Management (1976); B.A., San Francisco State College, 1963; M.B.A., George Washington Univ., 1971.

CLAIR ALTON PETERSON, Associate Professor of Operations Research and Economics (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

JAMES CLAY ROBERTSON, Lieutenant Commander, U.S. Navy; Instructor in Management (1976); A.B., Colgate Univ., 1967; M.B.A., Univ. of Virginia, 1974.

ROBERT WILLIAM SAGEHORN, Lieutenant Commander, U.S. Navy; Instructor in Management (1975); B.S., California Maritime Academy, 1959; B.A., Naval Postgraduate School, 1970; M.S., 1975.

NORMAN FLOYD SCHNEIDEWIND, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966.

JOHN DAVID SENGER, Professor of Management and Behavioral Sciences (1957); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

JONATHAN CILLEY TIBBITTS, JR., Commander, U.S. Navy; Instructor in Management (1975); B.A., Whitman College, 1958; BSCE, California Institute of Technology, 1958; MSCE, Stanford Univ., 1971.

RONALD ALFRED WEITZMAN, Associate Professor of Psychology (1971); B.A., Stanford Univ., 1952; M.A., 1954; Ph.D., Princeton Univ., 1959.

DAVID RICHARD WHIPPLE, JR., Associate Professor of Economics and Systems Analysis (1971); B.A., Univ. of St. Thomas, 1964; M.A., St. Mary's Univ., 1966; Ph.D., Univ. of Kansas, 1971.

CHESTER ARTHUR WRIGHT, Assistant Professor of Social Psychology (1973); B.A., San Francisco State

Univ., 1965; M.S., Univ. of California at Los Angeles, 1968.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Administrative Sciences.

MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in administrative sciences at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Administrative Sciences. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

1. A candidate for the degree of Master of Science in Computer Systems Management must complete satisfactorily either (A) a minimum of 56 quarter hours of graduate level course work or (B) a minimum of 48 quarter hours of graduate level course work and an acceptable thesis.
2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Computer Science
Data Processing
Economics
Financial Management and Accounting
Material Management
Operations Research
Statistics

MASTER OF SCIENCE IN MANAGEMENT

The award of the degree of Master of Science in Management requires:

1. Completion of the Management Fundamentals program plus a minimum of eight (8) quarter hours of upper division courses in subjects directly pertinent to the nature and objectives of the particular curriculum. The Management Fundamentals program consists of a total of 34 quarter hours of 2000 and 3000 level courses, including a minimum of the following hours by disciplines:

Accounting and Financial Management	6
Behavioral Science	3
Economics	6
Management Theory	3
Quantitative Methods	8

2. The completion of a minimum of forty (40) quarter hours of graduate level courses, at least twelve (12) quarter hours at the 4000 level.

3. The completion of an approved sequence of courses in the student's area of concentration. Examples of concentration areas are accounting and financial management, communications management, economics, management science, material management, personnel management, and systems acquisition management.

4. In addition to the 40 quarter hours of course work, the submission of an acceptable thesis on a topic previously approved by the Department of Administrative Sciences.

5. Final approval of a program leading to the Master of Science in Management shall be obtained for each student from the Chairman, Department of Administrative Sciences.

SERVICE COURSES

Upper Division Course

AS 2701 INTRODUCTION TO SYSTEMS ENGINEERING (3-0 to 4-0). This course provides the student with an introduction to system design and development, the underlying philosophy, concepts, and methodology of systems engineering, and its application in the Department of Defense and the Navy. It establishes the foundation for other courses in the Weapon Systems Technology

(WST) option of curriculum 530. Topics covered include systems engineering overview, the systems approach, the system life cycle and system design process, systems engineering disciplines. Emphasis is placed on the planning and design phases of the system life cycle. PREREQUISITE: None.

Upper Division or Graduate Courses

AS 3204 DEFENSE RESOURCE ANALYSIS (4-0). The aim of this course is to present the nature, the aims, and limitations of analysis as it exists today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the field of interest of the class will be discussed. PREREQUISITE: None.

AS 3340 THE DEFENSE DECISION PROCESS AND ASW (4-0). Study of the defense decision process as it related to the choice of ASW forces. Includes consideration of the systems acquisition system, the planning, programming and budgeting system, and their interrelationship in setting the ASW force level and mix. The effect of the office of Management and Budget, and the Congressional budget process on ASW forces is also considered. Current status of Soviet submarine employment, hardware and doctrine. PREREQUISITE: Last quarter standing in the ASW curriculum.

AS 3501 PROJECT MANAGEMENT (4-0). Study of practical application of management processes in the project and systems acquisition environment. Planning, organization, staffing, directing and controlling functions are discussed. Behavioral aspects of motivation, leadership and interpersonal processes are included. Enrollment restricted to non-systems acquisition management students. PREREQUISITE: None.

AS 3510 ORGANIZATIONAL BEHAVIOR AND NAVAL INTELLIGENCE (4-0). An examination of the different approaches to the study of public management and their relevance to the administration of naval intelligence. After a brief introduction to the organization theory, measures of organizational effectiveness and group decision making, a number of American intelligence organizations are analyzed. PREREQUISITE: GV 3061.

AS 3609 INTRODUCTION TO MATHEMATICAL ECONOMICS (4-0). A presentation of the basic economic concepts involved in the decision process of individuals and other entities faced with scarcity of resources. The goal is to provide sufficient background to allow accurate incorporation of economic incentives in descriptive and optimization models constructed in the process of doing systems analyses. Topics covered include opportunity cost, incremental analysis and its relation to decision rules, linear and nonlinear production processes, partial equilibrium analysis, ordinal and cardinal utility and welfare criteria. PREREQUISITES: MA 2110, MA 2042.

AS 3610 UTILITY THEORY AND RESOURCE ALLOCATION (4-0). Extension of the concepts discussed in AS 3609 to the analysis of decisions involving the warfare of groups of individuals. Covered are externalities, public goods, joint production, nonmarket decision making through shadow pricing. Also covered is an introduction to the macroeconomic structure within which the micro decisions previously covered are made. Included is income determination and sector anlaysis with policy discussions and evaluation. PREREQUISITE: AS 3609.

AS 3611 SYSTEMS ANALYSIS I (4-0). Principles of systems analysis and their relationship to the planning, programming, and budgeting system (PPBS), and the traditional OR models. Analysis of effectiveness measures and models. Cost estimating and analysis. Overall structure of cost-effectiveness and decision criteria. Risk and uncertainty problems. PREREQUISITES: OA 3604, AS 3610, PS 3303.

AS 3703 MAINTAINABILITY ENGINEERING (4-0). Maintainability as a system design discipline. The system life cycle/decision process and maintainability. The maintainability program plan (MIL-STD-470). Maintenance engineering analysis. Developing the maintenance concept. Concepts of system effectiveness - reliability, maintainability, availability, dependability, and capability. Maintainability statistics, prediction, demonstration, and evaluation (MIL-STD-471). Maintainability design requirements and trade-off analysis. Maintainability program management, design reviews, data collection. Case studies and examples. PREREQUISITE: OS 3202.

AS 3704 LOGISTICS ENGINEERING (4-0). In-

tegrated logistics support as a systems engineering discipline. Logistic support planning and the system life cycle. Logistics elements. Logistic support analysis (MIL-STD-1388). Level-of-repair analysis (MIL-STD-1390). Statistical techniques for logistics, resource analysis, provisioning and inventory control. Logistics interfaces with reliability and maintainability. Data requirements. Logistics management. PREREQUISITES: An introductory course in probability and statistics and a survey course in operations research.

Graduate Courses

AS 4613 THEORY OF SYSTEMS ANALYSIS (4-0). Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing decentralization of the decision-making problem. PREREQUISITES: AS 3611, OA 4631 (concurrently).

AS 4665 SYSTEMS PSYCHOLOGY (4-0). Course will be devoted to an examination of man's role and effectiveness as a system component. The major emphasis of the course is placed on the human aspects of the system. The course will examine human behavior in a systems context. Topics to be covered include motivation, perception and communication with emphasis being placed on the personnel sub-system and its interacting elements. This course is designed for the ASW curriculum. PREREQUISITE: OS 3665.

TELECOMMUNICATIONS SYSTEMS MANAGEMENT

CM 0001 SEMINAR FOR TELECOMMUNICATIONS MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

CM 0810 THESIS RESEARCH FOR TELECOMMUNICATIONS MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division or Graduate Course

CM 3184 REAL-TIME INFORMATION SYSTEMS (4-0). The study of real-time and on-line information systems from a functional and management standpoint. Topics covered are: the characteristics, effectiveness and system economics of selected DOD and civilian computer-communication networks and services; management of real-time system development and operations and analytical tools for evaluation of real-time systems. PREREQUISITES: CS 2103, MN 3105, OS 3211.

Graduate Course

CM 4184 REAL-TIME INFORMATION SYSTEM MANAGEMENT (4-0). This course, given in the final quarter of the Communications Management curriculum, integrates material presented in previous courses. Cases and examples are considered which are illustrative of the management problems confronting a communications manager in naval communication station or headquarters communications development activities. PREREQUISITES: CM 3184, EE 3425.

COMPUTER SYSTEMS MANAGEMENT

CT 0001 SEMINAR FOR COMPUTER SYSTEMS MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

CT 0810 THESIS RESEARCH FOR COMPUTER SYSTEMS MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Course

CT 2000 INTRODUCTION TO COMPUTER MANAGEMENT (3-2). This course will provide an introduction to the field of automatic data processing and the functions and responsibilities of the computer manager. Specific topics are: survey of contemporary computer applications, hardware and software; functions and responsibilities of the computer manager; introduction to the role of personnel management, financial management; quantitative methods and computer science in computer management; NPS Computer Center operations, including management functions, computer room operators, hardware, operating system and pro-

gramming. PREREQUISITE: None.

Upper Division or Graduate Course

CT 3220 COMPUTER CENTER OPERATIONS (3-2). Theory and practice of the management of computer center operations. Specific topics include: facilities planning, production scheduling and control, operational procedures, computer performance evaluation, analysis of operating systems and hardware for installation management, organization and management of personnel in computer installations and security of computer installations. A feature of the course is experience obtained in operating the NPS Computer Center installation. PREREQUISITES: CT 2000, CS 3010, CS 3020, CS 3030 concurrently, or equivalent.

Graduate Courses

CT 4182 DATA PROCESSING MANAGEMENT (4-0). Study of computer systems analysis and design. Management of ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: feasibility studies, selection, and acquisition of equipment; evaluation of computer hardware and software; installation and effective utilization of ADP equipment; and various types of computer applications. PREREQUISITE: A background of advanced work in information systems or computer science and Departmental approval.

CT 4185 COMPUTER-BASED MANAGEMENT INFORMATION SYSTEMS (4-0). The application and design of computer-based information systems for management planning, control and operations. This is a required course in the Computer Systems Management Curriculum and also is offered as an elective for other students who have taken the prerequisites. PREREQUISITES: CT 2000, MN 3155 or equivalent, and OS 3210 or equivalent.

MANAGEMENT

MN 0001 SEMINAR FOR MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

MN 0810 THESIS RESEARCH FOR MANAGEMENT STUDENTS. (0-0) Every student conducting thesis research will enroll in this course.

Upper Division Courses

MN 2031 ECONOMIC DECISION MAKING (4-0). The macroeconomic section includes a presentation of methods of national income determination, the consumption function and multiplier concepts and the impact of fiscal and monetary policies. The microeconomic section covers an introduction to individual economic decision processes and their relation to attainment of market equilibria. PREREQUISITE: MA 2300 concurrently.

MN 2106 INDIVIDUAL AND GROUP BEHAVIOR (4-0). A survey of individual and group behavior with emphasis on those aspects which affect performance and satisfaction within an organization. Topics include motivation, learning, personality, leadership, group effectiveness and role behavior. PREREQUISITE: None.

MN 2150 FINANCIAL ACCOUNTING (4-0). Study of the basic postulates and principles of accounting. Specific topics include the accounting cycle, asset valuation, equities and capital structure and financial statement analysis. PREREQUISITE: None.

Upper Division or Graduate Courses

MN 3001 BEHAVIORAL RESEARCH METHODOLOGY (4-0). Introduction to epistemology and the philosophy of science. Hypothetical construct, intervening variables and operational definitions will be discussed. An introduction to measurement and scaling will be given. Uses of inferential statistics and experimental method, both in the laboratory and in the field, will be examined. PREREQUISITES: MN 3105, PS 3211, and OS 3212 (concurrently).

MN 3002 HRM DATA ASSESSMENT (0-2). A laboratory course designed to apply quantitative methods to Human Resource Management data (e.g., Navy survey data), including the processing and the display of such data and the demonstration of practical HRM evaluation and data-based problems. PREREQUISITE: MN 3001 (concurrently).

MN 3101 PERSONNEL MANAGEMENT AND LABOR RELATIONS (4-0). Study of the princi-

ples and practices of personnel administration in business and government organizations. A survey of the history, development and current status of labor-management relations in industry and government. Analysis of the labor market and the implications of government regulations for wages and labor-management bargaining. PREREQUISITES: MN 3105, MN 3140, and MN 3161.

MN 3105 ORGANIZATION AND MANAGEMENT (4-0). The study of the management of organizations emphasizing human and organizational variables and their implications for managerial action. Topics include the theories of management, organizational behavior, planning and control, and organizational development. PREREQUISITE: MN 2106.

MN 3110 INDIVIDUAL BEHAVIOR (4-0). Study of the basic characteristics and determinants of individual behavior. Specific topics include personality, motivation, learning, behavior conditioning, and introduction to tests and measurement. Implications for effective administrative practice. PREREQUISITE: MN 2106.

MN 3111 PERSONNEL MANAGEMENT PROCESSES (4-0). A broad coverage of human behavior in the work situation with special emphasis on the problem of work in the Naval environment. Topical areas covered include selection, placement, training, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in organizations; equipment design and man-machine relationships; and consumer (user) behavior and the impact of technological programs. PREREQUISITES: MN 3105, PS 3211 (concurrently).

MN 3112 SELECTED TOPICS IN HUMAN RESOURCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3114 ORGANIZATION DEVELOPMENT I (3-0). The course will cover basic principles of intervention theory and method. What constitutes a "healthy" organization, how to diagnose it and how to involve its participants to improve it from the actual to the desired state are critical study problems. Cases, experiential teaching methods and interactive discussions will be employed. PREREQUISITE: MN 3105.

MN 3115 HUMAN RESOURCE DEVELOPMENT (0-4). A laboratory course designed to complement Organization Development I (MN 3114), it will focus on a special assessment of individual student competencies needed to become effective interventionists. An action plan for developing and improving these competencies will be required. PREREQUISITE: MN 3114 (concurrently).

MN 3116 HRM FIELD WORK (0-4). A laboratory course to accompany Organization Development II (MN 4123), it emphasizes general OD field trips, visits to ongoing military HRM interventions and a project designed to apply theory to practice. PREREQUISITE: MN 4123 (concurrently).

MN 3117 WORKSHOP DESIGN (0-4). A practicum designed as a companion course to Education and Training (MN 4116), to give students experience in designing, developing, implementing and assessing HRM workshops. PREREQUISITE: MN 4116 (concurrently).

MN 3120 PLANNING AND CONTROL (4-0). Theory and techniques of the management functions of planning and control. Topics will include policy and strategy formulation, long- and short-range planning, goal-setting and management by objectives, budgeting and forecasting, performance evaluation and the use of rewards. PREREQUISITE: MN 3105 and MN 3161.

MN 3121 LEADERSHIP AND GROUP BEHAVIOR (4-0). The study of groups in different settings and factors affecting both individual and group behavior. Attention will be given to such concepts as authority, conformity, cohesiveness, effectiveness, and leadership. Emphasis will be placed on methods of observing group action. PREREQUISITE: MN 2106.

MN 3122 COMPARATIVE CULTURES (4-0). A comparative look at organization structures, management philosophies, and supervisory techniques around the world. This cross-cultural analysis is prefaced by an introduction to the analysis of culture and social systems. Particular attention will be given to the problems of management in traditional societies undergoing modernization. PREREQUISITE: MN 3105.

MN 3123 SOCIOLOGICAL ANALYSIS (4-0). Survey of the general principles of the sociological

perspective in a symbolic interaction framework. Emphasis on processes and concepts including social interaction, aggregates, authority, roles, status, norms, culture, alienation, deviance, and the nature of social change. PREREQUISITE: MN 3105.

MN 3124 ANALYSIS OF BUREAUCRACY (4-0). An analysis of the forms and processes of complex organizations in evolution from charisma to bureaucracy. Topics include formal dimensions of structure, informal structure, professionalism, basic growth and elaboration processes, and applications of general systems theory to organizational phenomena. PREREQUISITE: MN 3105.

MN 3125 ORGANIZATIONAL BEHAVIOR AND ADMINISTRATION (4-0). Analysis of human situations and their administrative implications. The course focuses on the responses made by individuals and groups to the influences bearing upon their behavior in organizational settings. PREREQUISITE: MN 3105.

MN 3126 SELECTED TOPICS IN THE BEHAVIORAL SCIENCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3127 SELECTED TOPICS IN ORGANIZATION AND MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3130 MACROECONOMIC THEORY (4-0). Development of models to analyze the relationships between aggregate consumption, investment and output. Consideration of debt and financial assets, technical progress, growth, and monetary and fiscal control systems. PREREQUISITE: A course in Principles of Economics.

MN 3135 SELECTED TOPICS IN ECONOMICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in economics and Departmental approval.

MN 3140 MICROECONOMIC THEORY (4-0). Determination of the allocation of resources and the composition of output. Consumer and Producer Choice Theory. Partial and general equilibrium analysis. Welfare economics. Applications to defense problems are emphasized. PREREQUISITES: MN 2031, MA 2300 or their equivalents.

MN 3141 MICROECONOMICS (4-0). Study of the allocation of scarce resources to competing goals. Consumer behavior and utility theory. Theory of the firm. Analysis of alternative market structures. PREREQUISITE: A course in Principles of Economics.

MN 3142 INTERNATIONAL TRADE AND DEVELOPMENT (4-0). Study of the nature of trade between nations and the various approaches to economic development. Topics include trade and resource allocation, international finance, growth and development theory, and the market-public planning for development debate. Policy issues are considered with emphasis on the implications for national action. PREREQUISITE: A course in Principles of Economics.

MN 3143 MANAGERIAL ECONOMICS (4-0). Microeconomic theory and its applications and capital budgeting; significance of market structure upon performance, investment decisions and capital budgeting. Case and Industry studies. PREREQUISITE: A course in Principles of Economics.

MN 3146 COMPARATIVE ECONOMIC SYSTEMS (4-0). The characteristics and functions of economic systems. Criteria for evaluating performance. The analysis of alternative patterns of control, planning and market structures under capitalism, socialism, and mixed economies. PREREQUISITE: A course in Principles of Economics.

MN 3155 FINANCIAL AND MANAGERIAL ACCOUNTING (4-0). Study of both financial and managerial accounting. Introduces the accounting principles, practices and procedures associated with modern integrated systems. Specific topics include the accounting cycle, asset valuation, equities, capital, financial statement analysis, flexible budgets, cost volume profit analysis, and capital budgeting. *Closed to all students who must take MN 2150 and/or MN 3161.* PREREQUISITE: None.

MN 3161 MANAGERIAL ACCOUNTING (4-0).

Survey of cost accounting systems, including overhead costing, job order and process cost systems, variable and absorption costing, and standard costs. Emphasis is on applications of accounting data to planning, control and decision making. Topics covered include flexible budgets, variance analysis, cost-volume-profit analysis, and incremental profit analysis. Capital budgeting is examined extensively. PREREQUISITE: MN 2150.

MN 3165 SELECTED TOPICS IN ACCOUNTING AND FINANCIAL MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in accounting and financial management and Departmental approval.

MN 3170 DEFENSE RESOURCE ALLOCATION (4-0). The study of the process by which resources are allocated within the Department of Defense. Topics include an analysis of the planning, programming, and budgeting system and the systems acquisition process, cost-effectiveness analysis, and the economic, social and political environment of the military manager. PREREQUISITES: Financial and Managerial Accounting, Microeconomics or Managerial Economics, and a survey of operations research/system analysis.

MN 3172 PUBLIC POLICY PROCESSES (4-0). A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May also be offered as NS 3172.

MN 3183 MANAGEMENT INFORMATION SYSTEMS (4-0). Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in computer-based and other information systems. Study of basic computer and MIS concepts as required, including computer and data structure, input/output systems, file organization, programming and data-base management. PREREQUISITE: CS 2103 (concurrently).

MN 3184 MANAGEMENT INFORMATION SYSTEMS AND THE COMPUTER (4-0). Study of what an information system is, how the computer and other resources fit into the system, and management considerations involved in the Intelligence Data Handling System and other information systems. Study of basic computer and MIS concepts as required, including computer and data structures, input/output systems and file organization. Survey of COBOL programming and data-base management languages. This course is for 825 Naval Intelligence students only. PREREQUISITE: CS 0113 (concurrently).

MN 3215 SELECTED TOPICS IN MANAGEMENT SCIENCE (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3251 ACCOUNTING THEORY AND STANDARDS (4-0). Study of the basic concepts, standards, principles, and practices underlying published financial reports. Specific topics include approaches to the specification of accounting principles, bases of asset valuation, income measurement, and the measurement of corporate equities. Attention is devoted to current generally accepted accounting principles, to controversial reporting problems, and to prospective new developments. PREREQUISITE: MN 3161.

MN 3371 PROCUREMENT AND CONTRACT ADMINISTRATION (4-0). Study of the elements of the procurement process. Coverage includes the determination of requirements, techniques used in purchasing, the military-industrial complex and its role in providing material and service, the management of on-going programs, and the environment in which the acquisition takes place. Military procurement regulations are analyzed to determine their impact on efficient military logistics systems. PREREQUISITES: MN 3140 or MN 3141.

MN 3372 MATERIAL LOGISTICS (4-0). The quantitative analysis of material logistics systems and supply management problems. Elements of study include inventory theory, data reporting, forecasting, order processing, and system-wide design problems. PREREQUISITE: PS 3211 (concurrently).

MN 3373 TRANSPORTATION MANAGEMENT (4-0). Provides a knowledge of problems and practices encountered in the management of transporta-

tion systems. Areas covered include the study of present and future trends in military and commercial transportation systems. PREREQUISITES: MN 3140 or MN 3141.

MN 3374 PRODUCTION MANAGEMENT (4-0). This course examines the production process. Emphasis is distributed among the technical, managerial, and defense aspects of production. Topic coverage ranges from production planning through production control. PREREQUISITES: MN 3105 and PS 3211 and OS 3212.

MN 3376 SELECTED TOPICS IN MATERIAL LOGISTICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 3645 INVESTIGATIVE METHODS OF ECONOMICS I (4-0). Development and applications of econometric models of particular interest to public sector managers. Topics include demand forecasting, production function estimates and cost estimating. PREREQUISITES: MN 3140 or MN 3141, and OS 3212 (concurrently).

MN 3650 HEALTH ECONOMICS (4-0). An overview and analysis of the underlying elements of the continuing problems in the military and civilian health care delivery sectors. Elements covered are: organizational structure and change in the mode of delivery of health care; Supply, Demand and Output and Quality Measurement of health services; the impact of health care legislation; the interrelations of the military and civilian sectors. PREREQUISITES: Microeconomics, e.g., MN 3140, AS 3610 or equivalent.

MN 3760 MANPOWER ECONOMICS (4-0). This course contains both theoretical and empirical issues in manpower economics. The theoretical development emphasizes individual employment, job searching, mobility and career decisions. Empirical work presented will include studies on the all-volunteer force, hazardous duty compensation and reenlistment bonuses. PREREQUISITES: MN 3140 or 3141, or AS 3609.

MN 3801 SEMINAR IN TECHNOLOGY TRANSFER (4-0). The study of dissemination and utilization of technology and associated problems with emphasis on communications, sociology, and organizational factors. PREREQUISITE: MN 3105 or graduate standing in a technical curriculum with consent of Instructor.

MN 3811 - 3812 COMMUNICATION IN ORGANIZATIONS (4-0). A survey of current management strategies to more effectively employ human resources in achieving mission accomplishment. The organizational development approach to communication will be used to help students expand their communication skills. **MN 3811 intended for non-Management students; MN 3812 intended for Management students.** Graded on Pass/Fail basis only.

MN 3950 WORKSHOP IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 3960 READINGS IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 3970 SEMINAR IN MANAGEMENT (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking this course more than one time. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

Graduate Courses

MN 4105 MANAGEMENT POLICY (4-0). Study and appraisal of a variety of policies requiring the analysis of problems and the formulation of decision in both business and governmental enterprises. Use of case material, management games, and other devices as exercises in decision making and the executive action under conditions of uncertainty and change. PREREQUISITE: Open only to students in their final quarter of a Management Masters Program.

MN 4111 HUMAN RESOURCES SEMINAR (4-0). A combination of readings and individual student research reports in the area of human resource goals. Emphasis on empirical analysis. PREREQUISITE: Departmental approval.

MN 4112 PERSONNEL SELECTION AND CLASSIFICATION (4-0). Analysis of human performance within organizations. This course con-

siders the methods available for measuring and predicting the performances of the members of organizations. Methods of measuring differences between people via employment interviewing, testing, and life-history data are discussed. Techniques for studying and recording job behavior are also considered. In addition, the various strategies for personnel decisions are discussed in terms of validation, and selection and placement models. PREREQUISITES: MN 3111 or MN 3101.

MN 4113 PERSONNEL TRAINING AND DEVELOPMENT (4-0). Determination of skills, knowledges and attitudes in which people should be trained. Analysis of who should be trained and the methods currently available for training are discussed. Techniques available for evaluating the efficiency of training are also considered. PREREQUISITES: MN 3111 or MN 3101.

MN 4114 PERSONNEL PERFORMANCE EVALUATION (4-0). Current methods of appraising the work performance of individuals in different types of work are reviewed. Problems associated with each method are analyzed. Performance evaluation is examined as a system interfacing with selection, classification, training, advancement, and retention. PREREQUISITES: MN 3111 or MN 3101.

MN 4115 PERSONNEL MOTIVATION (4-0). A brief summary of the traditional theories of motivation is given. Several motivation to work theories are discussed along with the research concerning these theories. Current research on the roles of compensation in personnel motivation is considered. PREREQUISITE: MN 3110.

MN 4116 EDUCATION AND TRAINING (4-0). This course concentrates on adult learning theory, curriculum design and instructional technology to help students teach, develop and supervise curriculum and instruction. The course is especially oriented to the needs of the Human Resource Management community. PREREQUISITE: MN 3105.

MN 4121 ORGANIZATIONAL THEORY (4-0). This course provides an indepth theoretical perspective on complex organizations. It provides the student with conceptual tools for understanding the external environment, forms and structures, goals, systemic procedures and person-group-organizational interfaces. PREREQUISITE: MN 3105.

MN 4123 ORGANIZATION DEVELOPMENT II (3-0). A study of the field of organization development. The course provides knowledge and skills of organization development and consultative skills to improve organizational effectiveness. The course covers major theories of organization growth and development and a variety of OD strategies designed to improve organizational functions. Students will have opportunities to demonstrate and refine their individual skills in small group settings. PREREQUISITE: MN 3114.

MN 4126 SELECTED TOPICS IN THE BEHAVIORAL SCIENCES (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4127 SELECTED TOPICS IN ORGANIZATION AND MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Department approval.

MN 4133 ECONOMICS OF COMPUTERS (4-0). Analytical tools of microeconomics and statistics applied to decision making in computer management. Economics issues and legal constraints related to computer hardware and software systems are discussed. PREREQUISITES: MN 3143, PS 3000 or PS 3011 and CS 2103 or CT 2000.

MN 4142 INTERNATIONAL TRADE AND DEVELOPMENT POLICY (4-0). Leading issues in trade and development policy. Consideration of the implication of alternative economic systems on national policies. PREREQUISITE: MN 3142.

MN 4145 SYSTEMS ANALYSIS (4-0). This course will concentrate on the analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Systems analysis case studies will be emphasized. PREREQUISITES: MN 3172.

MN 4147 INDUSTRIAL RELATIONS (4-0). Development of the institutions and techniques for resolving conflict over wages and conditions of work. Theories of bargaining and arbitration. PREREQUISITE: MN 3101 or MN 3111.

MN 4151 INTERNAL CONTROL AND AUDIT-

ING (4-0). Study of the objectives and procedures of internal control in government and industry. Examination of the independent audit function, including auditing standards and reports. Study of internal auditing, with emphasis on operational audits. Consideration of the principal Federal audit organizations. Specialized topics including sampling techniques for auditing, audits of computer-based systems, and audit problems associated with selected assets and operations. PREREQUISITES: MN 3161, MN 3183, and PS 3211, or their equivalents.

MN 4152 DECISION MAKING FOR FINANCIAL MANAGEMENT (4-0). The management of the finance function in industry, with particular attention to defense contractors. Specific topics include cash and working capital management, long-term financing, determination of optimal capital structure, and valuation of a going concern. PREREQUISITES: MN 3161 and MN 3140 or equivalent.

MN 4153 SEMINAR IN ACCOUNTING AND CONTROL (4-0). Research and discussion of current developments and controversies in accounting and financial controls for government and industry. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3161 and permission of Instructor.

MN 4154 FINANCIAL MANAGEMENT IN THE NAVY (4-0). Review of financial management and fund control procedures in DOD and the Navy. Includes study of PPBS, Comptrollership, Budget Formulation and Execution, Headquarters and Field Accounting Systems, and Types of Navy Funds. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3161 and MN 3172.

MN 4161 FINANCIAL CONTROL SYSTEMS (4-0). Study of the structure and process of financial control in governmental organizations in general and DOD in particular. Specific topics include the basic concepts of management control, the measurement of inputs and outputs, pricing public services, programming, budgeting, accounting, and performance analysis. PREREQUISITES: MN 3105 and MN 3161.

MN 4162 COST ACCOUNTING (4-0). Review of various definitions of cost and alternative ways of measuring cost. Study of cost accounting systems, methods of allocating costs to cost objects, and the costing of activities, products, and projects. Consideration of the objectives and the substance of Cost Accounting Standards for negotiated defense procurement contracts. PREREQUISITE: MN 3161, PS 3211.

MN 4165 SELECTED TOPICS IN ACCOUNTING AND FINANCIAL MANAGEMENT (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in accounting and financial management and Departmental approval.

MN 4172 MARKETING STRATEGY (4-0). Research and study of areas of marketing that are applicable to management strategy. Typical areas to be considered are: sensitivity to the environment; value of analytical tools; behavioral considerations; creativity and innovative approaches; marketing research as a tool; influence of Federal statutes. PREREQUISITES: PS 3211.

MN 4181 APPLICATIONS OF MANAGEMENT INFORMATION SYSTEMS (4-0). Advanced study of management information as it relates to various organizational systems. Students will study actual industrial and/or military organizations in the context of management information systems. The issues of design, implementation, and operation of a management information system will be considered through the use of case studies of industrial and military organizations. This course is primarily for management students. PREREQUISITES: MN 3183.

MN 4185 SELECTED TOPICS IN INFORMATION SYSTEMS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITES: A background of advanced work in information systems and Departmental approval.

MN 4191 DECISION ANALYSIS (4-0). Discussion of the major topics of decision analysis, including decision theory, single- and multi-attribute utility theory, value of information, and modelling techniques. The course includes exposure to and use of computer models to structure and solve

problems. PREREQUISITE: OS 3212.

MN 4192 WORKSHOP IN MANAGEMENT SCIENCE (2-0 to 5-0). This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4193 SELECTED TOPICS IN MANAGEMENT SCIENCE (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4225 LABOR LAW (4-0). Labor Law as it affects management, labor and the public with special emphasis on legal problems confronting military personnel in managerial situations. PREREQUISITE: MN 3101.

MN 4371 PROCUREMENT POLICY (4-0). Case study appraisals of business and government procurement policies. Emphasis is on procurement decision making and policy formulation through the case analysis method. PREREQUISITE: MN 3371.

MN 4373 TRANSPORTATION POLICY (4-0). Advanced study in the management of transportation systems. Emphasis on coordinated transportation management in large-scale systems and its implication for DOD. PREREQUISITE: MN 3373.

MN 4376 SEMINAR IN MATERIAL LOGISTICS (4-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

MN 4650 THE MILITARY HEALTH CARE DELIVERY SYSTEM (4-0). This course is designed to acquaint the student with the structure and operation of the Department of Defense's system for providing health care to those eligible under current regulations; to identify current problem areas, and through application of systems analysis and management techniques to address the possible solutions to these problems in a course project. PREREQUISITE: MN 3650.

MN 4920 PUBLIC EXPENDITURE ANALYSIS (4-0). A presentation of basic concepts such as public goods, joint production and externalities which necessitate governmental market intervention. Techniques to analyze the effects and desirability of particular government expenditures are covered and include the theory of second best, cost-benefit analysis, consumer surplus, and social discounting. PREREQUISITES: MN 3140 and MN 3170 or 3172 or AS 3611.

MN 4941 MICROECONOMIC THEORY AND POLICY (4-0). Advanced study of equilibrium and disequilibrium microeconomic systems. Topics include consumer choice, producer choice, market structure, risk, imperfect competition and regulation, and economic planning models. Policy issues and their implication for national action. PREREQUISITE: MN 3140 or MN 3141 and Departmental approval.

MN 4942 THE STRUCTURE, CONDUCT AND PERFORMANCE OF THE DEFENSE INDUSTRIES (4-0). A study of selected defense industries structure (e.g., seller concentration, product differentiation, barriers to entry, demand for products, buyer concentration), conduct (e.g., pricing policy, product characteristics policy, policies toward rivals, policies toward customers), and performance (e.g., efficiency, progress, employment). The government as consumer and regulator. Typical industries covered are aerospace, computers, shipbuilding and telecommunications. PREREQUISITES: Microeconomics (MN 3140 or MN 3141 or MN 3143, or AS 3609).

MN 4945 SELECTED TOPICS IN ECONOMICS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in economics and Departmental approval.

MN 4950 WORKSHOP IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

MN 4960 READINGS IN MANAGEMENT (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITES: Departmental approval. Graded on Pass/Fail basis only.

MN 4970 SEMINAR IN MANAGEMENT (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking this course more than one

time. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

SYSTEMS ACQUISITION MANAGEMENT

SM 0001 SEMINAR FOR SYSTEMS ACQUISITION MANAGEMENT STUDENTS (0-2). Guest Lecturers. Thesis and research presentations. PREREQUISITE: None.

SM 0810 THESIS RESEARCH FOR SYSTEMS ACQUISITION MANAGEMENT STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division or Graduate Courses

SM 3301 INTRODUCTION TO SYSTEMS ACQUISITION (4-0). This course provides students with an overview of the Systems Acquisition process, its underlying philosophies and concepts, its application in the Department of Defense and the Navy, and establishes the foundations for other courses in the curriculum. Topics covered include the evolution of systems acquisition management, the systems approach, the system life cycle and defense system acquisition cycle, user-producer acquisition management disciplines and activities. PREREQUISITE: Enrollment in the Systems Acquisition Management curriculum.

SM 3302 FUNDAMENTALS OF PROJECT MANAGEMENT (4-0). Study of the principles of management as a body of knowledge related to practice. Discusses the functions of management planning, organizing, staffing, directing, and controlling — as they apply within industry and government. Specific application of these principles and functions to project management are investigated. PREREQUISITES: MN 2106 and SM 3301.

SM 3304 PROCUREMENT PLANNING AND CONTRACT NEGOTIATION (4-0). Study of the procurement planning and negotiation phases of the procurement cycle, including the determination of need, basic contract law, methods of procurement, fundamentals of the Armed Services Procurement Regulations and current procurement management techniques. Topics include procurement organizations, procurement by formal advertising and negotiation, source selection, pricing, types of contracts, structuring incentives, and the terms and conditions of contracts. PREREQUISITE: SM 3301.

SM 3305 CONTRACT ADMINISTRATION (4-0). This course stresses the management skills and techniques necessary for the successful administration of Government prime contracts and subcontracts. Topics include defense procurement contract administration, managing contract progress, change control, cost control, and contract termination. PREREQUISITE: SM 3304.

SM 3306 SYSTEMS EFFECTIVENESS CONCEPTS AND METHODS (4-0). An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing, Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness considerations. PREREQUISITES: OS 3202, OS 3203 (concurrently).

Graduate Courses

SM 4302 PUBLIC EXPENDITURE, POLICY AND ANALYSIS (4-0). The process of national decision-making particularly as reflected in the defense budgeting process. Models of budget decision making, including decentralization. Application of social choice concepts. Applications from the defense budgeting process. PREREQUISITES: MN 3161, MN 4145.

SM 4304 SEMINAR IN SYSTEMS ACQUISITION (4-0). Presentation of a wide selection of topics from current literature and research in systems acquisition. PREREQUISITES: SM 3305, SM 4305 or Department approval. Graded on Pass/Fail basis only.

SM 4305-4306 SYSTEMS ENGINEERING MANAGEMENT I-II (4-0). The objective of these courses is to provide the students with the opportunity to study real-world Navy project management decision-making. It covers technical management as applied to the systems acquisition process and stresses systems engineering disciplines and their life cycle integration with emphasis on performance, cost, and schedule trade-offs. The course is conducted by means of lectures and readings on systems engineering and the systems engineering disciplines, in-depth study of life-cycle management of selected Navy projects by teams of students, and participation in the Defense Management Simulation(DMS) exercise. PREREQUISITES: SM 3304, SM 3306.

DEPARTMENT OF AERONAUTICS

RICHARD WILLIAM BELL, Professor of Aeronautics; Chairman (1951)*; A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

ROBERT EDWIN BALL, Associate Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

MILTON HAROLD BANK, II, Assistant Professor of Aeronautics (1971); B.S., Naval Academy, 1957; B.S.A.E., Naval Postgraduate School, 1964; Engr., Stanford, 1967; M.S., Georgia Institute of Technology, 1970; Ph.D., 1971.

OSCAR BIBLARZ, Associate Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S. 1963; Ph.D., Stanford Univ., 1968.

DAVID WHITE CASWELL, CDR, U.S. Navy; Assistant Professor of Aeronautics (1974); B.S., Naval Academy, 1955; M.S. in A.E., Naval Postgraduate School, 1969; M.S. in I.R., George Washington Univ., 1972.

DANIEL JOSEPH COLLINS, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

THEODORE HENRY GAWAIN, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

CHARLES HORACE KAHR, JR., Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

DONALD MERRILL LAYTON, Associate Professor of Aeronautics (1968); B.S., Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954; M.S., Naval Postgraduate School, 1968.

GERALD HERBERT LINDSEY, Associate Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ. 1960; M.S. 1962; Ph.D., California Institute of Technology, 1966.

JAMES AVERY MILLER, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

DAVID WILLIS NETZER, Associate Professor of Aeronautics, (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ. 1962; Ph.D., 1968.

MAX FRANZ PLATZER, Professor of Aeronautics (1970); Dipl Ing., Tech. Univ. of Vienna, Austria, 1957; Dr. Techn. Sci., 1964.

LOUIS VINCENT SCHMIDT, Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

RAYMOND PARMOUS SHREEVE, Associate Professor of Aeronautics (1971); B.Sc., Imperial College, London, 1958; M.S.E., Princeton Univ. 1961; Ph.D., Univ. of Washington, 1970.

ROBERT DIEFENDORF ZUCKER, Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

EMERITUS FACULTY

WENDELL MAROIS COATES, Distinguished Professor Emeritus (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

ULRICH HAUPT, Associate Professor Emeritus (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

GEORGE JUDSON HIGGINS, Professor Emeritus (1942); B.S., in Eng.

(Ae.E.), Univ. of Michigan, 1923; Ae.E., 1934.

HENRY LEBRECHT KOHLER, Professor Emeritus (1943); B.S., in M.E., Univ. of Illinois, 1929; M.S. in M.E., Yale Univ., 1930; M.E., 1931.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of degrees as determined by the Aeronautics Department. In addition the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement for study in the Aeronautics Department generally is a baccalaureate in engineering earned with above average academic performance. This requirement can sometimes be waived for students who have shown distinctly superior ability in backgrounds other than engineering but who have had adequate coverage in the basic physical and mathematical sciences. All entrants must obtain the approval of the Chairman, Department of Aeronautics.

Students who have majored in Aeronautics, or who have experienced a significant lapse in continuity with previous academic work, initially will take preparatory courses in aeronautical engineering and mathematics at the upper division level, extending through the first two to three academic quarters and constituting a portion of the coursework for degrees in Aeronautics. Final approval of programs leading to degrees in Aeronautical Engineering must be obtained from the Chairman, Department of Aeronautics.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the degree program leading to the Master of Science in Aeronautical Engineering. However, students who have recently earned a degree with major in Aeronautics may apply for admission directly to the graduate program.

The Master of Science degree requires a minimum of 36 credit hours of graduate courses, of which at least 20 credit hours shall be at the 4000 level. It also requires that not less than 32 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 20 hours of courses in the Department of Aeronautics and a minimum of 8 hours in other departments.

An acceptable thesis is required for the degree unless waived by the Chairman, Department of Aeronautics, in which case 10 quarter hours of 4000 level courses in the disciplines of engineering, physical science, or mathematics will be required in addition to those specified above, increasing the total requirement to 46 quarter hours of graduate level credits.

AERONAUTICAL ENGINEER

Upon completing the preparatory courses, students may be selected on the basis of academic performance for the program leading to the degree Aeronautical Engineer. Selection to this degree program shall be limited to those students who, in the opinion of the faculty, have the potential to conduct the required research. The degree Aeronautical Engineer requires a minimum of 72 credit hours of graduate courses, of which at least 48 credit hours shall be at the 4000 level. It also requires that not less than 64 credit hours shall be in the disciplines of engineering, physical science or mathematics, and that this shall include a minimum of 36 hours of courses in the Department of Aeronautics and a minimum of 12 hours in other departments. An acceptable thesis is required for the degree.

Students admitted to work for the degree Aeronautical Engineer may be satisfying requirements for the Master of Science degree concurrently. The Master of

Science in Aeronautical Engineering may be conferred at the time of completion of the requirements for that degree.

DOCTORATE

The Department of Aeronautics offers programs leading to the doctorate in the fields of gasdynamics, flight structures, flight dynamics, propulsion and aerospace physics.

Entrance into the doctorate program may be requested by officers currently enrolled who have sufficiently high standing. The Department of Aeronautics also accepts officer students selected in the Navy-wide Doctoral Study Program, and civilian students selected from employees of the United States federal government.

All applicants who are not already enrolled as students in the Department of Aeronautics shall submit transcripts of their previous academic and professional records and letters of recommendation to the Department Chairman. The Chairman, with the advice of other department members, shall decide whether to admit the applicant to the Doctoral Program.

Every applicant who is accepted for the Doctoral Program will initially be enrolled in the AeE Program under a special option which satisfies the broad departmental requirements for the Engineer's degree and which includes research work. As soon as feasible, the student must find a faculty adviser to supervise his research and help him initially in the formulation of his plans for advanced study. As early as practicable thereafter, a Doctoral Committee shall be appointed to oversee that student's individual Doctoral Program as provided in the school-wide requirements for the Doctor's degree.

The degree requirements are as outlined under the general school requirements for the Doctor's degree.

In the event that a student is unable finally to satisfy the above requirements for the doctorate for any reason but has in the course of his doctoral studies actually completed all of the requirements for the degree of Aeronautical Engineer, he shall be awarded the latter degree.

AERONAUTICAL LABORATORIES

Five major laboratory divisions facilitate instructional and research programs in subsonic aerodynamics, structural test, rocket propulsion, turbomachinery, and gasdynamics.

The subsonic aerodynamics laboratory consists of two low-speed, continuous flow wind tunnels and a large continuous flow visualization tunnel. Standard techniques are used in the 32 x 45 inch and 42 x 60 inch wind tunnels to study basic fluid flow about bodies, stability and control of flight vehicles, and unsteady flows about bluff bodies and lifting surfaces. Helium bubble filaments are used in the 5 x 5 x 12 foot test section of the three-dimensional flow visualization tunnel to define flow fields of interest, e.g. about helicopter blades, and jet flap flow.

The structural test laboratory contains testing machines for static and dynamic tests of materials and structures, and an electro-hydraulic closed-loop machine for fatigue testing. Aircraft components as large as complete aircraft wings are accommodated on a special loading floor, where static and vibration tests are conducted. A well-equipped dynamics laboratory contains shaker tables, analog computers, and associated instrumentation. An adjacent strain gage and photoelastic laboratory provides support to test programs and instruction in structural testing techniques.

The rocket laboratory consists of an instrumented control room, a propellant chemistry laboratory, a high pressure air facility, and three test cells. The test cells are equipped for investigating solid, liquid, gaseous, and hybrid rocket combustion, and for studies of the internal ballistics of small caliber cannon. A solid fuel ramjet test facility is also in operation.

The advanced facilities of the turbomachinery laboratories are distributed in three buildings, one of which provides low speed tests with rectilinear cascades of large dimensions and an axial-flow three-stage compressor. A second building houses a centrifugal compressor test rig, instrumented for conventional performance measurements and for special

investigation of three-dimensional flows about both stationary and rotating vanes. The third building is used for high speed test of different types of turbomachines. Digital data acquisition and control equipment for steady-state and for real-time measurements at up to 100 kHz are available, with computer reduction and presentation on-line. Adjacent to this building is a hotspin test unit, where disks and propellers can be rotated at speeds up to 50,000 rpm while heated to temperatures of 1800°F.

The gas dynamics laboratory includes a 4 x 4 inch blowdown supersonic wind tunnel, a cold-driven, three-inch double-diaphram shock tube, and a 2 x 2 x 18 foot open-circuit oscillating flow wind tunnel. Laser interferometers, schlieren systems, and hotwire anemometers are used for flow observations. Ruby, He-Ne, argon, and CO_2 lasers are available; extensive use is made of laser holography. An electrohydrodynamic research facility permits studies of electric power generation and turbulence. A coaxial plasma accelerator has recently been completed.

In addition to the major laboratory facilities, there are fully instrumented ballistic ranges for studies of topics such as aircraft vulnerability, a composite materials fabrication laboratory, and a number of flight simulators used with hybrid computers and graphic displays in studying aircraft control problems and pilot/control system interactions. The Department also operates a three-ton surface effect ship testcraft of the captured air bubble type.

GENERAL PREREQUISITE REQUIREMENTS

Unless otherwise stated a preparatory set of aeronautics minicourses and mathematics courses, or equivalent preparation to be approved by the Chairman, Department of Aeronautics, is prerequisite to all other aeronautics courses.

AERONAUTICS

AE 0010 AERONAUTICAL ENGINEERING SEMINAR (0-1). Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

AE 0020 AERONAUTICAL ENGINEERING PROGRAM PLANNING (0-1). Oral presentations by the Aeronautics Academic Associate and faculty members involved in research with Aeronautics students on program planning, thesis requirements and research specialty areas. The course is to be given to each input during second quarter on board.

AE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

AE 2001 PARTICLE DYNAMICS (1-0). Principles of dynamics; absolute motion of particles; reference frames; relative motion of particles.

AE 2002 EQUATIONS OF MOTION, SYSTEMS OF PARTICLES (1-0). Equations of motion; work-energy and impulse momentum; moving reference frames; particle systems. PREREQUISITE: AE 2001.

AE 2003 RIGID BODIES (1-0). Rigid body planar kinematics, moments of inertia; equations of motion; work energy and impulse-momentum. PREREQUISITE: AE 2002.

AE 2004 SPACE KINEMATICS AND VIBRATING SYSTEMS (1-0). Rigid body space kinematics; vibrating systems; free and forced response. PREREQUISITE: AE 2003.

AE 2101 STATICS AND STRUCTURAL FUNDAMENTALS (1-0). Fundamental laws of mechanics (statics), vector arithmetic; analysis of reactions, statically determinate trusses, internal forces and moments, using method of sections and method of joints; schematic, free body, and internal force and moment diagrams, including sign conventions.

AE 2102-2103 STRESS AND STRAIN I-II (1-0). The first course introduces stress and strain concepts; equilibrium equations, symmetry of stress tensor; strain-displacement relations; engineering definitions and usages; bolted joints. The second

course covers transformation of stress and strain; Mohr's circles; Hooke's law, Young's modulus, Poisson's ratio; stress concentrations, elementary theories of failure; centroids and moments of inertia.

AE 2104 BENDING AND SHEAR IN BEAMS (1-0). Elementary formulae for bending and shear stresses; moment - curvature relations, second and fourth-order beam equations; solutions by direct integration, superposition; slope and deflection diagrams, semi-graphical solutions; statically indeterminate cases.

AE 2105 TORSION AND BUCKLING (1-0). Torsional stress and deflection on prismatic bars of circular cross-sections, handbook solutions for torsion on non-circular cross-sections. Beam-column and Euler column equations, eigenvalue solutions for buckling loads and modes; effect of boundary conditions; real, imperfect columns.

AE 2106 ENERGY THEOREMS IN STRUCTURAL ANALYSIS (1-0). Fundamental quantities defined; Castigliano's theorem; Method of Virtual Work; solution of statically indeterminate problems using Castigliano and Virtual Work.

AE 2107 THIN-WALLED STRUCTURES (1-0). Hydrodynamic analogy to shear flow; Bredt's formulae relating torsion and deflection to shear flow, shear center, shear flow due to torsion and bending of thin walled beams; effects of taper and cutouts; statically indeterminate cases; analysis of fuselage rings and stringers.

AE 2301 AERODYNAMIC FUNDAMENTALS (1-0). Dimensional analysis, Aerodynamic coefficients, Reynolds and Mach numbers. Gradient, divergence, curl and acceleration; physical significance and evaluation in common coordinate systems. Scalar and vector potentials. Stream function. Continuity equation. Gauss' and Stoke's theorems. Vorticity and circulation, Helmholtz laws.

AE 2302 INCOMPRESSIBLE FLOW (1-0). Pressure, gravity and viscous forces. Equation of motion. Energy distribution, Bernoulli's equation. Steady inviscid flows of uniform energy. Trailing vorticity. Irrotational motions, Biot Savart law. Momentum theorem. Elementary plane flows: souces, sinks, doublets. Flow about a circular cylinder with circulation. Kutta-Joukowski law.

AE 2303 THIN AIRFOILS IN PLANE FLOW (1-0). Vortex sheet model of thin airfoil Basic and additional lift. Fourier solution. Slope of lift curve. Ideal angle of attack. Aerodynamic center. Flat plate, circular arc, arbitrary and flapped airfoils.

AE 2304 BASIC AERODYNAMICS OF WINGS (1-0). Wing vortex system. Downwash. Lifting line model. Basic equation. Basic and additional lift. Fourier solution. Induced drag. Lift curve slope. Aerodynamic center. Spanwise loading for arbitrary planform and twist distribution. The horseshoe vortex. Interference and ground effects.

AE 2305-2306 AIRCRAFT PERFORMANCE I-II (1-0). The first course covers standard atmospheres and altimeter; defined airspeeds and the airspeed indicator. Machmeter; drag polar and flight polar; thrust and power required, climbing performance, ceilings; range and endurance at constant altitude. The second course covers cruise climb characteristics for range and endurance; energy management; turns, pull-ups. V-n diagram; take-off and landing. PREREQUISITE: AE 2301.

AE 2307 PRINCIPLES OF STATIC STABILITY AND CONTROL (1-0). Neutral and maneuver points; angle of attack and speed stability; control motions and forces to trim in straight and curved flight paths; trim tabs; CG limits. Principles are explained by graphical analysis of wind tunnel data, independent of AE 2310. PREREQUISITE: AE 2301.

AE 2308 DYNAMIC STABILITY — THE CLASSICAL MODES (1-0). Phugoid and short period longitudinal modes; third oscillatory mode and pitching divergence; rolling convergence, dutch roll and spiral lateral modes; root locus diagrams, effects of $C_{m\Omega}$; $C_{m\mu}$; stability boundaries. An independent course presenting solutions to equations of motion derived in AE 2311. PREREQUISITE: AE 2307.

AE 2309 THE STABILITY DERIVATIVES (1-0). Definition of the significant aerodynamic derivatives through which disturbances affect aircraft motions; discussion of the relative influence and roles of these derivatives in the classical dynamic modes. PREREQUISITE: AE 2308.

AE 2310 EQUATIONS OF STATIC STABILITY AND CONTROL (1-0). Wing-body-tail parametric representations; effects of wing downwash; tail vol-

ume; wing movement. Algebraic equations for preliminary design, exhibiting analytically the features explained graphically in AE 2307. PREREQUISITE: AE 2301.

AE 2311 LINEARIZED EQUATIONS OF DYNAMIC STABILITY (1-0). Derivation of equations used in AE 2308; transformation to rotating reference frame, Euler angles of aircraft orientation, stability axes and reference steady state, small disturbance approximation, linear air reactions, nondimensional system of parameters. PREREQUISITE: AE 2301.

AE 2312 CONFIGURATION VARIATIONS (1-0). Advanced airfoil concepts (supercritical airfoils, variable camber, vortex lift, jet flaps, etc.); direct lift and side force control; V/STOL developments; active controls technology, relaxed static stability; transonic and supersonic configurations. PREREQUISITE: AE 2308.

AE 2401-2402 BASIC THERMODYNAMICS I-II (1-0). Concepts of heat and work; First Law for a cycle and process (closed systems), enthalpy; Second Law, the heat engine, reversible process. Carnot cycle. Entropy, properties of substances in general; process calculations for steam, perfect gases, real gases.

AE 2403 BASIC FLUID FLOW (1-0). The control volume approach, equations of continuity, energy, and momentum for open systems; consequences of constant density; Rankine and Brayton cycles. PREREQUISITE: AE 2402.

AE 2404 INTRODUCTION TO VISCOUS FLOW (1-0). Viscosity concepts; friction losses in ducts, laminar and turbulent flow regimes; boundary layer concepts, pressure and friction drag. PREREQUISITE: AE 2403.

AE 2405 VARYING-AREA FLOW (1-0). Introduction to compressible flow; varying-area adiabatic flow, isentropic flow; general nozzle and diffuser performance. PREREQUISITE: AE 2403.

AE 2406 SHOCKS AND PRANDTL-MEYER FLOW (1-0). Standing and moving normal shocks; oblique shocks; Prandtl-Meyer flow; overexpanded and underexpanded nozzle operation. PREREQUISITE: AE 2405.

AE 2407 COMPRESSIBLE DUCT FLOW (1-0). Constant area adiabatic flow with friction (Fanno); constant area frictionless flow with heat transfer (Rayleigh). PREREQUISITE: AE 2406.

AE 2408 REACTION PROPULSION SYSTEMS (1-0). Types of propulsion engines and their cycles; calculation of net thrust; power and efficiency parameters; supersonic diffuser problems. PREREQUISITE: AE 2407.

AE 2409 MULTI-DIMENSIONAL FLOW (1-0). General formulation of continuity, energy, and momentum equations for 3-dimensional flow including the effects of viscosity, rotation and entropy production. PREREQUISITE: AE 2403.

AE 2410 SMALL PERTURBATION SOLUTIONS FOR FRICTIONLESS FLOW (1-0). Linearization of governing equations by method of small perturbations for case of isentropic flow; wavy wall solutions for subsonic and supersonic flow. PREREQUISITE: AE 2409.

AE 2811 AERONAUTICAL LABORATORIES I (0-2). A six-week course containing selected experiments in aero-structures. PREREQUISITES: AE 2101 through 2105. Graded on Pass/Fail basis only.

AE 2812 AERONAUTICAL LABORATORIES II (0-2). A six-week course containing selected experiments in dynamics. PREREQUISITE: AE 2001 through 2004. Graded on Pass/Fail basis only.

AE 2813 AERONAUTICAL LABORATORIES III (0-2). A six-week course containing selected experiments in subsonic fluid flow. PREREQUISITES: AE 2301 through 2307. Graded on Pass/Fail basis only.

AE 2814 AERONAUTICAL LABORATORIES IV (0-2). A six-week course containing selected experiments in supersonic fluid flow. PREREQUISITES: AE 2401 through 2106. Graded on Pass/Fail basis only.

Upper Division or Graduate Courses

AE 3321-3322 FLIGHT EVALUATION TECHNIQUES I-II (3-2). Quantitative and qualitative

techniques for the evaluation of aircraft performance in flight; aircraft data acquisition systems; normalizing and standardizing of flight test data; pilot rating scales; effects of design parameter on performance; laboratory flights in Departmental aircraft. Techniques for the evaluation of aircraft static and dynamic stability and control characteristics; flying qualities and handling qualities; variation of stability parameters; application of specifications to flight evaluations; maneuvering flight; laboratory flights in Department aircraft.

AE 3251 AIRCRAFT SURVIVABILITY/ VULNERABILITY (4-0). This course brings together all of the essential ingredients in a study of the survivability and vulnerability of fixed wing and rotary wing aircraft in a hostile environment. Topics to be covered include: actual SEA and Mid-East Losses — how many and why; the threat environment — small arms, AAA, SAM, AAM, lasers; S/V assessment methodology — the mission, aircraft description, vulnerability analysis, probability of kill, trade-off studies; survivability enhancement — minimize detection, aircraft design, ECM, tactics; vulnerability reduction-design improvements for fuel systems, flight controls, structures and materials, crew protection and the electrical system. In-depth S/V studies of the A-7, A-10, F-16, F-18, and P-3 will be presented. PREREQUISITES: SECRET clearance and U.S. Citizenship.

AE 3801 AERONAUTICAL DATA SYSTEMS (3-2). Equipment and procedures to be used in airborne and ground-based aeronautical laboratory measurement, recording, and analysis of parameters. Advanced applications of transducers, amplifiers, signal processors and recording devices. Statistical analysis of processed data.

AE 3900 SPECIAL TOPICS IN AERONAUTICS (2-0 to 5-0). Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Department Chairman.

Graduate Courses

(Note section on general prerequisite requirements)

AE 4101-4102 FLIGHT VEHICLE STRUCTURAL ANALYSIS I-II (3-2). Theory of plate and shell structures as applied to aircraft and spacecraft; rectangular and circular plates; composite and stiffened plates; vibration, stability, and large deflection of plates; membrane theory of shells of revolution; general theory of shells of revolution. Finite element stiffness method as applied to aircraft and spacecraft; energy theorems; stiffness matrices for structural elements; refined and isoparametric elements; matrix displacement method; analysis of substructures; current aerospace computer programs; structural modeling techniques; dynamics and stability of elastic systems; synthesis and optimization.

AE 4131-4132 SOLID MECHANICS FOR AERONAUTICAL ENGINEERS I-II (3-2). Theory of elasticity applied to aircraft problems beginning with the formulation of the three-dimensional field equations and continuing with engineering solutions by means of classical analytical methods, approximate energy methods, photoelastic methods and numerical methods. Further development of elasticity theory to provide the application of stress analysis methods in assessing ultimate structural integrity of aircraft structures through theories of failure, fracture mechanics, fatigue and buckling.

AE 4139 SPECIAL TOPICS IN SOLID MECHANICS (4-0). Selected advanced coverage of topics in solid mechanics including: plasticity, viscoelasticity, general stability, thermoelasticity, nonlinear elasticity, wave propagation, etc. May be repeated for credit if taken with different topics. PREREQUISITE: Consent of Department Chairman.

AE 4271 DESIGN PROBLEMS IN AERONAUTICS I (3-3). A complex engineering problem in the field of flight vehicles is presented for solution by systems-oriented methods, with the primary purpose of developing basic understanding for the design process. Integration of various disciplines, evaluation of airworthiness requirements, real-life complexities, and team work with clearly assigned responsibilities are emphasized. PREREQUISITE: Consent of Department Chariman.

AE 4272 DESIGN PROBLEMS IN AERONAUTICS II (3-3). Continuation of AE 4271.

AE 4273 SUBSONIC AIRCRAFT DESIGN (3-2). The course centers on a preliminary design project individually formulated by each student to meet given specifications. The end product is a three-

view supported by aerodynamic design calculations. PREREQUISITES: AE 2305-06.

AE 4274 AIRCRAFT STRUCTURAL DESIGN (3-2). A continuation of subsonic aerodynamic design into the structural design of the wing and fuselage. The end product will be a wing and fuselage structural layout including stringer number and size, skin thicknesses, rib spacing, spar cap sizes, etc. PREREQUISITES: AE 2101-06.

AE 4301 FLIGHT VEHICLE RESPONSE (3-2). Topics in stability and control of flight vehicles including the effects of crosscoupling and aeroelasticity; state space formulation and solutions, controlability and observability.

AE 4302 ROTARY WING AERODYNAMICS (3-2). Topics in the performance, stability, and control characteristics of rotary wing aircraft. Hover, level flight, vertical climb and climbing forward flight. Ground effect. Power requirements.

AE 4305 V/STOL AIRCRAFT TECHNOLOGY (3-2). Types of V/STOL aircraft: fundamental principles, main performance characteristics and propulsion requirements; STOL technology: high lift devices, jet flaps, augmentor wings; VTOL technology: flow vectoring devices, lift engine and lift fan technology, augmentor wings, airframe/propulsion system interactions; V/STOL stability and control considerations.

AE 4316 STRUCTURAL DYNAMICS (3-2). Response of discrete and continuous elastic structures to transient loads and to steady oscillatory loads utilizing matrix methods. Manual and computer methods of calculation. An introduction to random vibrations may also be offered as an optional topic at the discretion of the instructor.

AE 4317 AEROELASTICITY (4-0). Static aeroelasticity problems in aircraft; non-stationary airfoil theory; strip and lifting surface concepts. Application to the flutter problem. Transient loads, gusts, buffet, and stall flutter.

AE 4341-4342 GUIDANCE AND CONTROL FOR AEROSPACE SYSTEMS I-II (3-2). Fundamental characteristics of feedback systems; time and frequency domain analysis of linear systems; state variable analysis; stability determination; root locus and frequency response diagrams; analog computer simulation of control systems. State vector solutions for continuous and sampled data systems; introduction to nonlinear systems; Liapunov's second method; optimal and modal control concepts; random processes; human pilot modeling.

AE 4401 ADVANCED THERMODYNAMICS (3-2). Reactive mixtures, kinetic theory, transport phenomena, quantum statistics; partition functions, thermodynamic properties.

AE 4402 COMBUSTION (3-2). Reacting gas mixtures, combustion temperature, chemical kinetics, combustion generated pollutants, detonations and deflagrations, laminar and turbulent flame theories and experimental results, flame stabilization, gas turbine combustor design. PREREQUISITE: AE 4401.

AE 4431 AEROTHERMODYNAMICS OF TURBOMACHINES (4-0). Application of fundamental laws of fluid dynamics and thermodynamics to the analysis of flows in turbomachines. AE 4831 concurrently.

AE 4432 ADVANCED THEORY OF TURBOMACHINES (4-0). Advanced theory and methods for design and performance prediction of turbomachines. PREREQUISITE: AE 4431, AE 4832 concurrently.

AE 4451-4452 AIRCRAFT AND MISSILE PROPULSION I-II (3-2). Description of various propulsion methods: rockets, ramjets, gas turbines, and briefly, space propulsion; includes parameters that specify system performance, information on current state of art and impact of trends in propulsion technology, thrust and drag; discussion of components; inlets, combustors, nozzles; creative thinking is encouraged by discussion of novel propulsion schemes, stressing relationship to gas dynamics, mechanics and aerothermodynamics. Components are assembled, conceptually to form ramjets, turbofans, etc., for which performance (SFC, thrust) is predicted; several missions (e.g., fighter aircraft, air-to-air missile) are defined and the best propulsion system is selected for each application.

AE 4501 ADVANCED GASDYNAMICS (4-0). Similarity and perturbation methods applied to two-dimensional subsonic, supersonic and trans-

onic flow. Shock wave interactions and reflections with reference to the hodograph plane. Method of characteristics: unsteady, and supersonic. Influence of viscosity and heat conduction on gas dynamics. Some computer problems in gas dynamics.

AE 4502 HYPERSONIC FLOW AND REAL GAS EFFECTS (3-2). Real gas effects will be studied (dissociation, ionization) with reference to problems such as Couette flow, the wavy wall, and Prandtl-Meyer flow. Some hypersonic flow with emphasis on small perturbation analysis, similarity solutions and Newtonian flow. PREREQUISITE: AE 4501.

AE 4503 AERODYNAMICS OF WINGS AND BODIES (3-2). Study of three-dimensional wings and bodies in subsonic and supersonic flow. Slender body theory and flow reversal theorems. Singluar perturbation problems and unsteady flow with some computer problems.

AE 4504 MAGNETOFLUIDDYNAMICS (3-2). Magnetohydrodynamic flows. Advanced energy conversion and propulsion systems which employ magneto/electrofluiddynamic principles. Definition and review of pertinent physical concepts. Current and future applications.

AE 4505 LASER TECHNOLOGY (3-2). Survey of different types of lasers, including gaseous, solid state, gasdynamic and chemical lasers, resonator cavities, gaussian beams and propagation mechanisms; high energy lasers and military applications of lasers: PREREQUISITE: Consent of Instructor. (may also be taught as ME 4505)

AE 4511 BOUNDARY LAYER THEORY (4-0). Some exact solutions of the Navier-Stokes equations. Boundary layer concept and equations, momentum and energy integrals, stability and transition. Fundamentals of turbulent flow; laminar and turbulent boundary layers with arbitrary pressure gradients. Techniques of solution.

AE 4512 CONVECTIVE HEAT AND MASS TRANSFER (4-0). Convective heat and mass transfer in ducts and from exposed surfaces; laminar and turbulent flows. Analytic techniques, integral and numerical methods, experimental correlations. Effects of variations in thermophysical properties. Combined heat and mass transfer. PREREQUISITE: AE 4511.

AE 4632 COMPUTER METHODS IN AERONAUTICS (3-2). Computer solutions of ordinary and partial differential equations for aerospace structures, gas dynamics, flight mechanics, dynamics and heat transfer problems. Equilibrium, eigenvalue and propagation problems in discrete and continuous systems. Introduction to computer design, computer graphics, hybrid computer, and systems simulation. PREREQUISITE: MA 3232.

AE 4831 TURBOMACHINERY LABORATORY I (0-3). Measurements of the performance of turbomachines. PREREQUISITE: AE 4431 concurrently.

AE 4832 TURBOMACHINERY LABORATORY II (0-3). Detailed investigations of stationary and rotating components of turbomachines. PREREQUISITE: AE 4432 concurrently.

AE 4900 ADVANCED STUDY IN AERONAUTICS (2-0 to 5-0). Directed graduate study or laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of Chairman.

ANTISUBMARINE WARFARE

The Antisubmarine Warfare Academic Group has administrative responsibility for the academic content of the Antisubmarine Warfare Program. Teaching in this program is carried out by faculty members attached to the various Academic Departments associated with the Program.

ROBERT NEAGLE FORREST, Associate Professor of Operations Research; Chairman (1964)*; B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

DONALD CHARLES DANIEL, Assistant Professor of Political Science (1975); B.A. Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

CARL RUSSEL JONES, Professor of Administrative Sciences (1965); B.S., Carnegie Institute of Technology; 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

WARREN CHARLES THOMPSON, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

ALAN ROBERT WASHBURN, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

CARROLL ORVILLE WILDE, Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of an interdisciplinary program carried out in accordance with the following degree requirements:
   a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included and in three disciplines, a course at the 4000 level must be included.
   b. An approved sequence of at least three courses constituting advanced specialization in an option area must be included.
   c. In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.
   d. The program must be approved by the Chairman of the ASW Group.

SYSTEMS TECHNOLOGY

ST 0001 SEMINAR (0-1). Special lectures, and discussion of matters related to the ASW Program. PREREQUISITE: SECRET clearance.

ST 0810 THESIS RESEARCH/GROUP PROJECT (0-1). Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

ST 1810 INTRODUCTION TO PROGRAMMABLE CALCULATORS (1-1). Programming and use of keyboard functions, data storage and retrieval, printers, plotters, subroutine packages. This course is designed for students in the Antisubmarine Warfare and Weapons Engineering curricula. PREREQUISITE: None. Graded on Pass/Fail basis only.

ST 3000 STUDY PROJECT ON ASW SYSTEMS PERFORMANCE (0-2). This project is the study and analysis of the performance of an assigned type of ASW system under a variety of realistic operating conditions. Graded on a Pass/Fail basis. PREREQUISITE: Enrollment in ASW curriculum or consent of curriculum coordinator, SECRET clearance.

AVIATION SAFETY PROGRAMS

CLYDE HENRY TUOMELA, Captain, U.S. Navy; Director (1974)*; B.S., Stanford Univ., 1959; M.S. George Washington Univ., 1972; War College, 1972.

RUSSELL BRANSON BOMBERGER, Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; Ll.B., LaSalle Univ., 1968; J.D., 1969; M.A. Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

CRAIG MERRILL BRADBURY, Commander, U.S. Navy; Instructor in Advanced Safety Management and Aircraft Accident Investigation (1976); B.S., Naval Postgraduate School, 1963.

JOHN ROBERT JOHNSON, Lieutenant Commander; U.S. Navy; Instructor in Safety Program Management and Aircraft Accident Prevention (1976); B.A., Drury College, 1960.

EDWARD JOHN KENNEDY, Associate Professor of Aviation Physiology (1972); M.D., Univ. of Iowa College of Medicine, 1962.

JAMES CHRISTIAN NIELSEN, Associate Professor of Aeronautical Engr. and Safety; (1966); B.S.A.E., Univ. of Washington, 1950; M.S.A.E., 1957.

GEORGE EDWARD TUCKER, Captain, U.S. Marine Corps; Instructor in Aeronautical Engineering and Safety (1977); B.S., U.S. Naval Academy, 1968.

LEWIS EDWARD WALDEISEN, Commander; U.S. Navy; Assistant Professor of Operations Research for Human Factors Engineering (1974); B.S., Univ. of San Francisco, 1960; M.A., Univ. of New Mexico, 1965; Ph.D., Texas Tech Univ., 1974.

LESTER CHARLES WIBLE, Assistant Professor of Aviation Accident Prevention and Crash Investigation (1965); B.S., Naval Academy, 1945.

**The year of joining the Postgraduate School Faculty is indicated in parenthesis.*

AVIATION SAFETY OFFICER COURSE

An Aviation Safety Officer (ASO) course is offered eight times per year on a temporary additional duty basis for those commands needing a trained Aviation Safety Officer. The course prepares aviation safety officers at the squadron level to assist commanding officers in conducting an aggressive accident prevention program. When the ASO completes this course he will be able to organize and administer an accident prevention program at the squadron level as defined in OPNAVINST 3750.14 and 5100.8.

This 6 week course consists of approximately 185 classroom hours of safety program management, including mishap prevention techniques, operational aerodynamics and aircraft structures, mishap investigation and reporting, psychology, law, and aviation physiology. Prior completion of college level courses in algebra and/or physics is highly desirable. Two class field trips will be conducted: a safety survey of an operating squadron or air station; and an industrial activity tour.

Designated naval aviators and naval flight officers of the Navy and Marine Corps of the rank of Lieutenant, USN, and Captain, USMC, and above are eligible to attend. Exceptions must be approved by Type Commanders, or CMC, as appropriate. Details of quota control and class schedules are defined in CNETNOTICE 1520.

ADVANCED SAFETY MANAGEMENT COURSE

An Advanced Safety Management (ASM) course is offered four times per year on a temporary additional duty basis to provide additional safety education beyond the ASO level for officers assigned to major aviation staffs, the Naval Safety

Center, aircraft carriers, air stations, carrier air wing staffs and similar organizations.

This course consists of approximately 138 classroom hours of such subjects as safety management concepts; computer systems data analysis; safety-identified hardware; industrial safety (including Occupational Safety and Health Act concepts); and shipboard safety. A field trip to an airline maintenance base will be conducted.

Enrollment in the ASM course is limited to officers currently occupying staff aviation safety billets or proceeding to such duty. A prerequisite for the ASM course is completion of either the ASO course, the former Survey of Aviation Safety course, or at least one year's experience in a safety billet. Eligible officers without this prerequisite should be ordered to attend both the ASO and ASM courses. Details of quota control and class schedules are defined in CNET NOTICE 1520.

RESIDENT COURSES

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Aviation Safety Officer Certificate by completing the program requirements: AO 2020, AO 2030, AO 3000, AO 3040, AO 3050, and AO 3060. Substitutions for some of these courses may be made by taking equivalent courses in other departments upon approval of the Director of Aviation Safety. Examples: AO 2020 may be replaced by upper division or graduate courses in aeronautical engineering covering similar topics. AO 3040 may be replaced by upper division or graduate courses in psychology covering similar topics.

Officers regularly enrolled in other curricula of the Postgraduate School may qualify for the Advanced Safety Management Certificate by completing ASM program requirements. Prospective ASM candidates must have completed the Aviation Safety Officer program described above, or its equivalent, prior to enrolling in ASM course. Specific ASM course requirements include AO 3100 and AO 3120.

AVIATION SAFETY COMMAND COURSE

An Aviation Safety Command (ASC) course is offered five times a year on a temporary additibnal duty basis to commanding officers and executive officers of aviation commands. This course consists of 41 hours in such subjects as hazard identification, mishap histories, legal constraints, result of safety surveys of aviation activities, and failure modes. No academic credit is available for this course.

AVIATION

Upper Division Courses

AO 2020 AERODYNAMICS FOR AIRCRAFT ACCIDENT PREVENTION AND INVESTIGATION (3-0). Survey of aerodynamics, performance, stability and control of flight vehicles. Critical areas of operation, contribution of operator techniques, effects of varying configurations, design deficiencies, and manufacturing defects.

AO 2030 AIRCRAFT STRUCTURAL ANALYSIS (1-0). Strength of materials, design criteria, failure mechanisms. Recognition of failures, fatigue, brittle fractures, contribution of manufacturing and maintenance, analysis of evidence, corrosion control technology, and quality control concepts.

Upper Division or Graduate Courses

AO 3000 PROBLEMS IN ACCIDENT PREVENTION AND INVESTIGATION (0-4). Problem-solving exercises in the application of systems safety concepts in the organization of squadron accident prevention and investigation effort. Developed primarily through case-study methods, the course emphasizes conservation of resources, cost effectiveness, and systems management in accident prevention, investigation, and reporting.

AO 3040 SAFETY PSYCHOLOGY (1-0). Study of human reliability in survival-value environments; personality elements in safety motivation; identification and reduction of problems in human reliability.

AO 3050 SAFETY LAW (1-0). Study of leading cases and statutes concerning rights and duties in the safety disciplines. Emergency claims; quasi-contractural duties. Criminal prosecution of safety violations. Legal duties of care. Special rules of evidence used by the courts in safety-related disputes.

AO 3060 PROBLEMS IN AVIATION MEDICINE (1-0). Life-science considerations in accident prevention and investigation. Medical prediction. Effects of hypoxia, dysbarism, G-forces, spatial disorientation, diet, drugs, and exercise upon flight capabilities. Recognition of emotional difficulties; emotional considerations in accident-prevention. Interpretation of autopsy reports.

AO 3100 MANAGEMENT OF ACCIDENT-PREVENTION PROGRAMS (3-2). Management theories, practices, communications, and controls; automatic data-processing and analysis of accident statistics; legal consideration in safety management; use of systems safety in hazard identification.

AO 3120 TECHNOLOGICAL ASPECTS OF ACCIDENT-PREVENTION AND ANALYSIS (3-2). Topics include case studies of technological design-related avaiation mishaps; identification of structural failure modes; computer and simulator methods in aeronautics; safety-related problems of Navy weapons-system evaluation and acquisition.

DEPARTMENT OF COMPUTER SCIENCE

CHARLES PHILIP GIBFRIED, Commander, U.S. Navy; Assistant Professor of Computer Science and Operations Research; Acting Chariman (1975)*; B.S., Univ. of Illinois; 1958; M.S., Naval Postgraduate School, 1972.

GERALD LEONARD BARKSDALE, JR., Assistant Professor of Computer Science and Mathematics (1969); B.S.E.E., Rice Univ., 1965; M.S.E.E., 1966; M.S.C.S., Univ. of Wisconsin at Madison, 1972; Ph.C., 1972.

GERALD GERARD BROWN, Associate Professor of Computer Science and Operations Research (1976); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

RICHARD WESLEY HAMMING, Adjunct Professor of Computer Science (1976); B.S., Univ. of Chicago, 1937, M.S., Univ. of Nebraska, 1939; Ph.D., Univ. of Illinois 1942.

STEPHEN TRYGVE HOLL, Lieutenant Commander, U.S. Navy; Assistant Professor of Computer Science (1976); B.S. U.S. Naval Academy, 1967; Ph.D., The Johns Hopkins Univ., 1974.

CYNTHIA EMBERSON IRVINE, Research Associate (1975); B.A. Rice Univ., 1970; Ph.D., Case Western Reserve Univ., 1975.

GARY ARLEN KILDALL, Associate Professor of Computer Science and Mathematics (1972); B.S. Univ. of Washington, 1967; M.S., 1968; Ph.D., 1972.

UNO ROBERT KODRES, Associate Professor of Mathematics and Computer Science (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

NEIL PATRICK MILLER, Lieutenant Colonel, U.S. Marine Corps; Instructor in Computer Science and Administrative Sciences (1976); B.A., Univ. of California at Berkeley, 1956; B.A., Southern Colorado State College, 1965; M.S., Naval Postgraduate School, 1966.

VICTOR MICHAEL POWERS, Assistant Professor of Electrical Engineering and Computer Science (1970); B.S., Univ. of Michigan, 1963; M.S.E.E., 1964; Ph.D., 1970.

GARY MICHAEL RAETZ, LT. U.S. Navy; Instructor in Computer Science and Mathematics (1973); B.S. Portland State Univ., 1972; M.S., Naval Postgraduate School, 1973.

GEORGE ANTHONY RAHE, Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

LYLE VERNON RICH, Lieutenant, U.S. Navy; Instructor in Computer Science and Mathematics (1975); B.S., Illinois State Univ., 1969; M.S., Naval Postgraduate School, 1971.

RONALD JAY ROLAND, Lieutenant Colonel, U.S. Air Force, Assistant Professor of Computer Science (1976); B.S. Colorado State Univ., 1969; M.S., Univ. of Hawaii, 1971; A.B.D., Univ. of Nebraska, 1977.

NORMAN FLOYD SCHNEIDEWIND, Professor of Computer Science and Information Science (1971); B.S.E.E., Univ. of California at Berkely, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. The degree of Master of Science in Computer Science will be awarded upon the satisfactory completion of a program, approved by the Chairman, Computer Science Department, which satis-

fies, as a minimum, the following degree requirements:

A. At least 40 quarter hours of graduate level work of which at least 12 quarter hours must be at the 4000 level.

B. The program shall include at least:

	Quarter Hours
Computer Science	20
Operations Research, Electrical Engineering, and/or Management.	9
Mathematics, Probability, and Statistics	11

C. Completion of an approved sequence of courses constituting specialization in an area of Computer Science.

D. Completion of an acceptable thesis in addition to the 40 quarter hours of course work.

LABORATORY FACILITIES

The Computer Science Department has cognizance over the Postgraduate School's Computer Laboratories. The Signal Processing Laboratory is an interconnected computer complex consisting of a medium sized digital computer, two high performance interactive display systems, a large general purpose hybrid/analog computer and multiple terminals and display equipment. Two PDP-11/50 computers and a CSPI-125 signal processing computer have been combined into a multiprocessing system which supports four different types of displays and sixteen time sharing terminals. A Military Systems Laboratory features a general purpose computer capable of emulating current military hardware such as AN/UYK-7 and AN/UYK-20 computers. The Microcomputer Laboratory consists of a variety of microprocessors; included among these are multiple Intellec 8-80 systems supported by floppy-disk units and a Sycor System supporting four time-sharing terminals. All of the above facilities are available school-wide for hands-on use in instructional and research programs. In addition, the computational resources of the W.R. Church Computer Center provides support for timesharing and batch processing.

COMPUTER SCIENCE

CS 0001 SEMINAR (0-1). Special lectures; guest lecturers; discussion of student thesis research faculty research projects. PREREQUISITE: None.

CS 0110 FORTRAN PROGRAMMING (3-0). The basic elements of FORTRAN are covered. Practical application of the principles is afforded by means of a series of problems of increasing difficulty.

CS 0113 COBOL PROGRAMMING (3-0). The basic elements of COBOL are covered. Practical application of principles is afforded by means of a series of problems of increasing difficulty. Television lectures.

CS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

CS 2010 INTRODUCTION TO COMPUTERS AND DATA PROCESSING FOR NON-COMPUTER SCIENCE MAJOR (2-0). An introduction to the general characteristics of contemporary computers and to the functions they serve in a diversity of organizations, emphasizing the capabilities of the computer, the limitations of computing and the economics of data processing in general. There are no prerequisite or corequisite courses. Prior computing experience is not assumed and programming is not taught.

CS 2100 INTRODUCTION TO FORTRAN PROGRAMMING (1-2). This course is designed to provide the student with a basic familiarity in FORTRAN. The course is intended for the student who is already familiar with programming in a higher level language. The course will normally be taught in either a PSI or self-instructional mode. PREREQUISITE: CS 2110, CS 2010, or consent of Instructor.

CS 2103 INTRODUCTION TO COBOL PROGRAMMING (1-2). This course is designed to provide the student with a basic familiarity in COBOL. The course is intended for the student who is familiar with programming in a higher level language. The course may be taught in either a PSI or self-instructional mode. PREREQUISITE: CS 2110, CS 2010, or consent of Instructor.

CS 2105 SURVEY OF COMPUTERS AND PROGRAMMING (4-0). A general appreciation of computer history, computer system organization, computer applications and computer management. Flowcharting and coding in an algorithmic language. Not recommended for anyone intending to take further courses in computer science. PREREQUISITE: None.

CS 2107 INTRODUCTION TO THE CMS-2 COMPILER LANGUAGE (1-2). This course is designed to provide the student with a basic familiarity in CMS-2. The course is intended for the student who is familiar with programming in a higher level language. The course may be taught in either a PSI or self-instructional mode. PREREQUISITE: CS 2110 or consent of Instructor.

CS 2110 INTRODUCTION TO COMPUTERS AND PROGRAMMING FOR COMPUTER SCIENCE MAJORS (3-2). Algorithmic problem solving. Emphasis on symbol manipulation more than numeric computation. Basics and characteristics of computers and computer solutions of problems. Programming and timesharing systems. Basic machine operations and assembly-level programs. PREREQUISITE: None.

CS 2520 MATHEMATICAL MODELING AND PROGRAMMING (4-2). Programming as applied to basic numerical techniques (iterative approximation methods, numerical solution of ordinary differential equations). Experiments with examples from weapon systems performance. PREREQUISITE: CS 2700, PS 3411, PS 3419 and MA 2121.

CS 2600 INTRODUCTORY COMPUTING AND COMPUTER SCIENCE FOR OPERATIONS ANALYSTS (2-0). An introduction to computer problem solving methods for students in the Operations Research curriculum. Topics include subprograms, numerical error control and numerical methods and program organization and debugging. Emphasis is placed on actual computer programming experience with 5-7 operations research related projects of increasing difficulty. Classroom examples and assigned projects are drawn from first quarter Operations Research courses. PREREQUISITES: CS 0110 or experience in FORTRAN programming.

CS 2700 INTRODUCTION TO COMPUTER PROGRAMMING WITH FORTRAN (2-2). An introduction to the characteristics of general purpose digital computers, and the fundamentals of algorithmic problem solving emphasizing the flow-charting method. Basic computer programming in the FORTRAN language, primarily directed toward the solution of numerical problems and matrix manipulation, including the use of library subroutines. Students who have taken a previous FORTRAN course (CS 0110, CS 2100 or CS 2600) should not enroll in this course.

Upper Division or Graduate Courses

CS 3010 COMPUTING DEVICES AND SYSTEMS (3-0). This course will provide a survey of peripheral computer devices, computer memories, the central processing unit and their interaction and means of communication. Consideration will be given to the various arrangements of data in the different storage devices in relation to the writing and retrieving of this data. Specific equipment in the NPS computer center and computer laboratory will be examined in detail in a hands-on environment and consideration given to interaction, correction and circumvention of inoperative units. PREREQUISITE: CT 2000.

CS 3020 PROGRAM DEVELOPMENT: STRUCTURE, DESIGN, AND LANGUAGES (3-4). This course will provide the student with broad background in the concept, design and development of computer programs. The subject of language selection, program evaluation, testing and debugging, and program documentation will be covered in the lecture portion of the course. The laboratory session will be devoted to the development of programming skills and practices as discussed in the lectures, using the American National Standards Institute COBOL language. Projects assigned during the course will be tested, debugged and run in the NPS computer center. PREREQUISITES: CT 2000, CS 2110 or equivalent background or consent of Instructor.

CS 3030 OPERATING SYSTEMS STRUCTURES (5-0). This course will provide a broad overview of operating system including memory management techniques, job scheduling, processor scheduling, device management and data (information) management techniques. Case studies will be included to illustrate the manager-operating system interfaces, including time usage accounting, error processing and recovery, operating system selection, data control and security, and operating

system utility support. In addition future trends in computers will be investigated, including maxi, mini, and microcomputers. PREREQUISITES: CS 3010 and CS 3020 or equivalent background and consent of Instructor.

CS 3111 FUNDAMENTAL CONCEPTS IN STRUCTURAL PROGRAMMING LANGUAGES (4-0). An introduction to the significant features of programming languages. Formal definition of a language including specification of syntax and semantics. Characteristics of assemblers, compilers and interpreters. Properties of block structured languages, including scope of declarations, storage allocation and subroutines. Basic programming techniques, including string manipulation, list processing, bit manipulation and recursion. PREREQUISITES: Either CS 2100, CS 2103, CS 2110 or consent of the Instructor.

CS 3112 OPERATING SYSTEMS (4-0). This course is an introduction to the fundamental concepts of operating systems and system software. Topics to be discussed include multiprogramming, multiprocessing, dynamic relocation, paging, segmentation and virtual memory. Timesharing, process scheduling, system communication and auxiliary storage management are also included. Currently available digital computer systems are compared to demonstrate these concepts. PREREQUISITES: CS 2110 and CS 3111.

CS 3113 INTRODUCTION TO COMPILERS (3-2). This course is intended to explore the basics of modern compiler design and construction techniques. The fundamentals of scanning, grammar based parsing and compiler semantics are developed in the framework of modern compiler-compiler and translator-writing system technology. The laboratory periods will be used to develop a small model compiler/assembler. Modern languages and current NPS research will be used as examples whenever possible. PREREQUISITES: CS 3111 or consent of the Instructor.

CS 3204 DATA COMMUNICATIONS (4-0). Quantitative study of communication processes with emphasis on digital communication. Concepts fundamental to the engineering of accurate, efficient communication links and systems. Elements of information theory. Communication channels and their capacity, encoding and decoding of data over noisy channels. Error detection and correction coding schemes and procedures. Techniques and devices for effective data transmission in computer-based systems. PREREQUISITES: EE 2810, PS 3401.

CS 3230 MICROCOMPUTERS (3-2). Microcomputer organization. Instruction repertoire. Higher level languages for microcomputers. Interfacing microcomputers with other computer systems and external digital equipment. Systems design using microcomputers as systems elements. The laboratory sessions are devoted to projects which familiarize the student with the practical aspects of systems design. PREREQUISITES: CS 3111, EE 2810 or equivalent.

CS 3300 INFORMATION STRUCTURES (3-0). Basic concepts of data. Linear lists, strings, arrays, and orthogonal lists. Representation of trees and graphs. Storage systems and structures, and storage allocation and collection. Symbol tables and searching techniques. Sorting (ordering) techniques. Formal specification of data structures, data structures in programming languages, and generalized data management. PREREQUISITES: CS 3111.

CS 3310 ARTIFICIAL INTELLIGENCE (4-0). Definition of heuristic versus algorithmic methods, rationale of heuristic approach, description of cognitive processes and apporaches to mathematical invention. Objective of work in artificial intelligence, simulation of cognitive behavior and self-organizing systems. Heuristic programming techniques including the use of list-processing languages. Survey of examples from representative application areas. The mind-brain problem and the nature of intelligence. Class and individual projects to illustrate basic concepts. PREREQUISITE: CS 2110 or CS 3111.

CS 3502 REAL-TIME INTERACTIVE COMPUTER SYSTEMS (3-2). This course presents a study of the hardware and software requirements of real-time, near real-time, and interactive computer systems. Concepts of system software including multiprogramming, multiprocessing, data structures, memory management, and facilities for user-computer interaction are presented. Interrupts, interactive device concepts including graphic displays, data transmission techniques and other hardware support concepts are included. A set of DOD and civilian computer systems will be examined to determine and compare characteris-

tics, effectiveness and system economies of various real-time computer systems. Introduction to system characteristics is facilitated by laboratory work in which interactive systems are used to demonstrate concepts presented in the classroom. PREREQUISITES: CS 2105, CS 2110, or the equivalent.

CS 3510 REAL-TIME COMBAT DIRECTION SYSTEMS AND STRUCTURES (3-2). Basic principles of hardware and software structures and interactions in real-time systems. Operating systems; interrupts, multiprocessing, multiprogramming. Data flow in inter- and intra-computer communication. Operation and management of peripherals. Evaluation and interpretation of component specifications in terms of computer system capabilities. PREREQUISITES: CS 2520 or EE 2810, or CS 2700.

CS 3601 AUTOMATA AND FORMAL LANGUAGES (3-0). Logical networks, neural networks, finite automata, minimalization of automata, regular expressions, context-sensitive languages and linear bounded automata. Ambiguity in formal languages. PREREQUISITES: MA 2025 and MA 3026 or equivalent.

CS 3800 DIRECTED STUDY IN COMPUTER SCIENCES (0-2 to 0-8). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the Instructor. Graded on Pass/Fail basis only.

CS 3900 SELECTED TOPICS IN COMPUTER SCIENCE (3-0). Presentation of a wide selection of topics from current literature. Lectures on subjects of current interest and exploration may be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School. Tours of other facilities of interest may also be conducted. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

Graduate Courses

CS 4112 COMPUTER SYSTEMS (4-0). System design concepts in computer hardware-software combinations. Software engineering: specification, design, documentation and testing of complex computer programs. Memory, control and capability protection. Resource allocation mechanisms, policies and problems. File system organization. Analysis, simulation and measurement techniques and their application to computer system design. Concepts are presented in terms of the fundamental insight provided by considering timesharing systems. PREREQUISITE: EE 2810, CS 3112.

CS 4113 COMPILER DESIGN AND IMPLEMENTATION (3-2). This course extends the concepts introduced in CS 3113. The methods and techniques of grammar analysis and parsing are developed with particular emphasis on LALR(1) based systems. The problems of dynamic versus static run time memory allocation; code generation; intermediate languages; error detection/analysis/correction at compile/run time; code optimization and multipass compilation are developed in additional detail. Laboratory periods will be used for analysis of existing compilers. PREREQUISITES: CS 3113 and CS 3300 or consent of the Instructor.

CS 4200 SYSTEM ANALYSIS AND DESIGN (4-0). This course covers system development including the basics of analysis, design and testing; system description tools including decision tables, flowcharts, state diagrams and system description techniques; system analysis tools; system analysis procedures; as well as important design issues such as hardware/software compatability, operating system compatability and information system requirements. PREREQUISITES: Completion of upper level CS series or consent of Instructor.

CS 4202 INTERACTIVE COMPUTATION SYSTEMS (3-2). A study of the man-computer interface and methods for computer-assisted problem solving. System facilities for man-computer interaction. Computer graphics, transformations and graphics software. Data structures, memory requirements, storage, file, and data management. Languages for man-computer interaction including graphics, command, problem-oriented, and special purpose languages. Laboratory work includes individual projects using interactive graphical consoles. PREREQUISITES: EE 2810, CS 3112, CS 3300 pre or corequisite, or consent of Instructor.

CS 4300 DATA BASE SYSTEMS (4-0). This course explores the technology of current Data Base Systems. The course deals with the historical development of Data Base Systems, current technology and future trends. The primary emphasis is the logical view of data base implementations, including the hierarchy, network and relational models and the language extensions requried to support such systems. PREREQUISITES: CS 3112 and CS 3300, or CS 3030 and consent of Instructor.

CS 4320 DATA BASE SYSTEM DESIGN (4-0). CS 4320 explores the design of Data Base Systems and current technology of Data Base software. Implementation techniques, viable alternatives, data base philosophies, data manipulation in complex information environments, and system requirements are explored. Examples of systems will be drawn from active DoD data base systems and current application/research in the private as well as public sectors. PREREQUISITE: CS 3020 or a knowledge of COBOL, or other higher level language, and consent of the Instructor.

CS 4800 DIRECTED STUDY IN ADVANCED COMPUTER SCIENCE (0-2 to 0-8). Directed advanced study in computer science on a subject of mutual interest to student and staff member. Intended primarily to permit students to pursue in depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. A written report to the department chairman is required at the end of the quarter. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0). This course examines topics in the fields of current research in computer science. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

DEPARTMENT OF ELECTRICAL ENGINEERING

DONALD EVAN KIRK, Professor of Electrical Engineering; Chairman (1965)*; B.S., Worchester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1965.

ORESTES METHODIUS BAYCURA, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute of Technology, 1957; M.S., Univ. of Pittsburgh, 1959; D.Sc., 1963.

JOHN MILLER BOULDRY, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

STEPHEN BREIDA, Associate Professor of Electronics (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

ROBERT WARD BURTON, Lieutenant Colonel, U.S. Air Force; Associate Professor of Electrical Engineering (1973); B.S., U.S. Naval Academy, 1955; S.M. (E.E.), Massachusetts Institute of Technology, 1960; E.E., 1960; Ph.D., Harvard Univ., 1964.

SHU-GAR CHAN, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1954; M.S. Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

MITCHELL LAVETTE COTTON, Associate Professor of Electronics (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

JOHN HENRY DUFFIN, Professor of Electrical Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

GERALD DEAN EWING, Associate Professor of Electrical Engineering (1963); B.S.E.E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E., Oregon State Univ., 1962; Ph.D., 1964.

ALEX GERBA, JR. Associate Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

DAVID BOYSEN HOISINGTON, Professor of Electronics (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

STEPHEN JAUREGUI, JR., Associate Professor of Electrical Engineering (1971); B.A., Univ. of California at Berkeley, 1956; M.S., Naval Postgraduate School, 1960; Ph.D., 1962.

CLARENCE FREDERICK KLAMM, JR., Professor of Electronics (1951); B.S., Washington Univ., 1943; M.S., 1948.

JEFFREY BRUCE KNORR, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

GEORGE HEINEMANN MARMONT, Professor of Electronics (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

GLEN ALLEN MYERS, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E. Stanford Univ., 1956; Ph.D., 1965.

HERBERT LeROY MYERS, Assistant Professor of Electrical Engineering (1951); B.S., Univ. of Southern California, 1951.

JOHN EVERETT OHLSON, Associate Professor of Electrical Engineering (1971); B.S., Massachusetts Institute of Technology, 1962; M.S.E.E., Stanford Univ., 1963; Ph.D., 1967.

RUDOLF PANHOLZER, Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule in Graz, Austria, 1953; D.Sc., 1961; M.S.E.E., Stanford Univ., 1956.

SYDNEY RICHARD PARKER, Professor of Electrical Engineering; (1966); B.E.E., City College of New York, 1944; M.S. Stevens Institute of Technology, 1948; Sc.D., 1964.

JOHN PATRICK POWERS, Associate Professor of Electrical Engineering (1970); B.S.E.E., Tufts Univ., 1965; M.S., Stanford Univ., 1966; Ph.D., Univ. of California at Santa Barbara, 1970.

VICTOR MICHAEL POWERS, Assistant Professor of Electrical Engineering (1970); B.S.E.E., Univ. of Michigan, 1963; M.S., 1964; Ph.D., 1970.

GEORGE ANTHONY RAHE, Professor of Electrical Engineering and Computer Science (1965); B.S., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

CHARLES HARRY ROTHAUGE, Professor of Electrical Engineering (1949); B.E., John Hopkins Univ., 1940; D. Eng., 1949.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D. Stanford Univ., 1964.

ABRAHAM SHEINGOLD, Distinguished Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

DONALD ALAN STENTZ, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S. Naval Postgraduate School, 1958.

ROBERT DENNY STRUM, Associate Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

TIEN-FAN TAO, Professor of Electrical Engineering (1971); B.S., National Taiwan Univ., 1955; M.S., Univ. of Pennsylvania, 1958; Ph.D., Harvard Univ., 1963.

GEORGE JULIUS THALER, Distinguished Professor of Electrical Engineering (1951); B.E., John Hopkins Univ., 1940; D.Eng., 1947.

HAROLD ARTHUR TITUS, Professor of Electronics (1962); B.S., Kansas Univ., 1952; M.S. Stanford Univ., 1957; Ph.D., 1962.

JOHN THOMAS VINSON, Commander, U.S. Navy; Instructor in Electrical Engineering (1976); B.S. Naval Postgraduate School, 1967, M.S., 1972.

JOHN ROBERT WARD, Professor of Electrical Engineering (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

MILTON LUDELL WILCOX, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938; M.S., Univ. of Notre Dame, 1956.

JOHN McREYNOLDS WOZENCRAFT, Professor of Electrical Engineering (1977); B.S., U.S. Military Academy, 1946; M.S., Massachusetts Institute of Technology, 1951; E.E., 1951; Ph.D., 1957.

EMERITUS FACULTY

WILLIAM MALCOLM BAUER, Professor Emeritus (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S., Harvard Univ., 1929; D.Sc., 1940.

JESSE GERALD CHANEY, Professor Emeritus (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

PAUL EUGENE COOPER, Professor Emeritus (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

EDWARD MARKHAM GARDNER, Professor Emeritus (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

GEORGE ROBERT GIET, Distinguished Professor Emeritus (1925); A.B., Columbia Univ., 1921; E.E., 1923.

RAYMOND KENNETH HOUSTON, Professor Emeritus (1946); B.S.,

Worcester Polytechnic Institute, 1938; M.S., 1939.

ROBERT LEE MILLER, Professor Emeritus (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

RAYMOND PATRICK MURRAY, Associate Professor Emeritus (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

CHARLES BENJAMIN OLER, Professor Emeritus (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., John Hopkins Univ., 1950.

WILLIAM CONLEY SMITH, Professor Emeritus (1946); B.S., Ohio Univ., 1935; M.S., 1939.

JOHN BENJAMIN TURNER, JR., Associate Professor Emeritus (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

ALLEN EDGAR VIVELL, Dean Emeritus (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

RICHARD CARVEL HENSEN WHEELER, Professor Emeritus (1929); B.E., Johns Hopkins Univ., 1923; D. Eng., Rensselaer Polytechnic Institute, 1926.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific academic requirement for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

1. A minimum of 40 quarter hours of graduate work beyond the requirements for the Bachelor of Science in Electrical Engineering degree shall be required for the degree of Master of Science in Electrical Engineering. The academic records of those students who do not complete the requirements for the Bachelor of Science in Electrical Engineering degree at the Naval Postgraduate School will be evaluated by the Department of Electrical Engineering to determine what additional undergraduate courses need to be taken to qualify for entry into the graduate program. Of the 40 quarter hours a minimum of four courses, of at least 12 hours must be in the course sequence 4000-4999. At least 30 hours shall be required in Electrical Engineering subjects. An acceptable thesis must be presented. Approval of all programs must be obtained from the Chairman, Department of Electrical Engineering.

2. An acceptable thesis for the Engineer's Degree may be accepted as meeting the thesis requirements of the Master's Degree. However, the thesis requirement for the Master's Degree may be waived upon the approval of the Chairman of the Department under the following circumstances:

a. The student has been admitted to the Engineer's Degree, Doctor of Engineering or Doctor of Philosophy Degree program.

b. The student has completed four (4) 4000 level courses of a minimum of twelve (12) credits over and above the course requirements for the Master's Degree.

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in electrical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Electrical Engineering Department. A total minimum of 12 quarter hours at the 4000

level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer. Normally this program is of three years' duration. Candidates for the Engineer's degree are selected during their second year in residence.
2. A minimum of 80 graduate course credits are required for the award of the Engineer's degree. Of these at least 30 hours are to be in courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman Department of Electrical Engineering.

DOCTOR OF PHILOSOPHY AND DOCTOR OF ENGINEERING

The Department of Electrical Engineering has an active program leading to the degrees of Doctor of Philosophy and Doctor of Engineering. Areas of special strength in the department are signal processing, communications systems, electronic systems and devices and control theory. Joint programs with other departments are possible. A noteworthy feature of the program leading to the Doctor of Engineering degree is that the student's research is conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the Federal Government. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

ELECTRICAL ENGINEERING LABORATORY

The Electrical Engineering Department Laboratories have excellent facilities in almost all phases of modern electrical engineering. At present the laboratories are divided into Communications and Navigation, Microwaves and Antennas, Radar and Electronic Countermeasures, Signal Processing and Digital Systems, General Measurements, Solid State and Thin Films, Lasers, Control Systems, Sonar, Energy Conversion, and Bio-Engineering Laboratories. There are extensive service facilities including a calibration laboratory where a continuous program of calibration and maintenance of laboratory instruments is carried out.

In addition to the usual experimental and instructional type laboratories, status as a Naval facility enables the Department to utilize a number of modern systems as adjuncts to the laboratory. These include communications, radar, telemetry, sonar, countermeasures and navigational systems.

Students in the Department have access to the Computer Center (IBM/360 System) as well as the Computer Laboratory which is a school-wide direct access computer complex where each student may program and operate the computer system for the solution of his own problem. The facility includes a medium size digital computer, two high performance input-output display units, and a general purpose hybrid/analog computer; all integrated into a single system. These facilities support a wide range of research and instruction in digital and hybrid computation and simulation.

As a part of the laboratory facility, there are generous research spaces available for thesis students to conduct their research problems on an individual basis.

BIOENGINEERING/BIOMEDICAL STUDIES

The Department of Electrical Engineering has responsibility for the biology courses listed below. These courses together with certain ones offered by other departments can be included, as appropriate, in the curriculum of a student interested in a bioengineering/biomedical program as part of his studies toward a degree.

Upper Division or Graduate Courses

EE 3800 CELLULAR AND MOLECULAR BIOLOGY (4-0). The fundamental principles of

the living cell covered from a biochemical and biophysical standpoint. The structure and role of macromolecules in the cell is studied; in particular DNA, RNA and their relations to cell function, to the synthesis of proteins, and to genetics. PREREQUISITES: CH 3401, and a course in probability and statistics.

EE 3801 HUMAN PHYSIOLOGY (5-0). A comprehensive course in mammalian physiology, emphasizing human functional aspects. PREREQUISITE: EE 3800.

EE 3820 BIOELECTRONIC INSTRUMENTATION (3-3). The application of electronic methods to biological and medical measurements is treated in depth. The special problems involved, such as design of electrodes and input amplifiers, and the conversion of data to meaningful parameters are studied. The laboratory includes actual measurement procedures, using living material. PREREQUISITES: EE 3801, EE 2103, EE 2212 or equivalent.

Graduate Courses

EE 4840 NEURAL SIGNAL PROCESSING AND CONTROL (3-3). This course extends the coverage of neurophysiology beyond that given in EE 3801 Human Physiology. Lecture material describes the basic structure and performance of neural circuits, especially those involved in multisynaptic reflex arcs, including inhibitory action, and those involved in muscular control. Associative and integrative functions of the fore brain are studied. The laboratory part consists of experiments using living material and projects where basic models of neural processes would be set up and their performance measured, using real time computer processing as appropriate. PREREQUISITES: EE 3801, EE 3802, EE 2103, EE 2212, CS 2700 or equivalent.

EE 4880 ADVANCED TOPICS IN HUMAN PHYSIOLOGY (4-0). Recent advances in the study of human physiological systems are presented. The areas covered include circulation and heart, renal function, metabolic interrelations, endocrine systems and their control, immunology, and recent research in neurophysiology and the special senses. PREREQUISITES: EE 3801, EE 4840.

EE 4890 COMPUTER MODELING OF BIOLOGICAL SYSTEMS (2-4). This is a seminar and project type course. Its exact content will vary with the interests of the instructors and students. However, examples of models of biological systems, as reported in the current literature, will be studied, and, as laboratory projects, one or more new models will be devised and analyzed, using computer techniques. PREREQUISITES: EE 3801, EE 4840, EE 4414, or equivalent. A stochastic modeling course such as OA 3704 is desirable.

DEFENSE COMMUNICATIONS

Upper Division Course

CO 2111 DEFENSE TELECOMMUNICATIONS ORGANIZATION AND PLANNING (4-0). Organization and functions of Department of Defense Telecommunications Systems, including command and control functions. A study of the National Communications System, Defense Communications Systems, and the complete Naval communications organization, including the Naval Security Group Integration of the various organizational systems is emphasized. The role of communications in the Naval Planning process is studied as well as an introduction to communications planning. Course is structured to include supportive field trips to nearby telecommunications facilities and seminars on subjects of current telecommunications interest.

Upper Division or Graduate Course

CO 3112 INTEGRATED DEFENSE TELECOMMUNICATIONS SYSTEMS (4-0). Brief review of Defense Tactical and Strategic Integrated Telecommunications Systems followed by in depth analysis of technical and managerial problems associated with current and programmed automated telecommunications systems. Course entails field trips to telephone, satellite and automatic telecommunications switching centers in conjunction with seminars on current supportive telecommunication topics. PREREQUISITES: CO 2111, MN 3105, MN 3170, MN 3183. U.S. Citizenship and SECRET Clearance are required.

ELECTRICAL ENGINEERING

EE 0110 REVIEW OF BASIC ELECTRICAL CONCEPTS (5-0). Topics include the current-voltage relations in simple circuits, circuit laws and theorems, elementary AC circuit concepts, physical definitions of circuit constants and laws of electron motion. A six week refresher course.

EE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

EE 0951 SEMINAR (0-1). Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

EE 0960 THESIS TOPICS SEMINAR (0-1). Introductory presentations by NPS faculty members of current research projects. Intended to inform first-year students of potential thesis areas.

Upper Division Courses

EE 2101 BASIC CIRCUIT THEORY (3-2). An introduction to electrical engineering circuit theory; concepts of charge, current, voltage, energy and power; Sources, resistance, capacitance and inductance; Kirchhoff's current and voltage laws; loop and nodal analysis; network theorems. PREREQUISITES: Integral calculus and MA 2045 (may be concurrent).

EE 2102 CIRCUIT ANALYSIS (4-2). Solution of network equations using the Laplace transform method; network functions, poles and zeros and stability; sinusoidal steady-state analysis; frequency response; Fourier series; network theorems; two-part networks. PREREQUISITES: EE 2101 or equivalent.

EE 2103 LINEAR SYSTEMS ANALYSIS (4-2). Mathematical modeling; convolution; state variable equations and solution; signal flow graphs; simulation of linear systems on digital and analog computers. PREREQUISITES: EE 2102; differential equations; complex variable theory and FORTRAN (may be concurrent).

EE 2104-2105 ELECTRICAL ENGINEERING FUNDAMENTALS I-II (3-2) and (4-2). The physical principles of electrical engineering are presented, followed by basic circuit analysis; topics covered are power and response in electrical circuits including single phase and three phase systems; electronic principles are introduced. Electronic devices and their models are considered; amplifiers and principles of feedback leading to the system concept are presented; magnetic circuits and electromagnetic to mechanical energy conversion principles are studied; the Laplace transform and the transfer function concept are included. Primarily for scientific and non-electrical engineering curricula. PREREQUISITE: MA 1100 (may be concurrent).

EE 2107 INTRODUCTION TO ELECTRICAL ENGINEERING (4-2). The first in a sequence of courses designed for the Weapon Systems Technology curriculum. Electrical quantities; basic circuit elements; simple circuits; circuit laws; circuit analysis; electronic building blocks. PREREQUISITE: Calculus.

EE 2108 LINEAR SYSTEMS ANALYSIS (4-2). The second in a sequence of courses designed for the Weapons Systems Technology curriculum. Formulation of system models including state equations, transfer functions and system diagrams; analytical methods for solving system equations; digital and analog computer solution of system models; frequency response analysis. PREREQUISITES: EE 2107, MA 3139 or equivalent (may be taken concurrently).

EE 2111 ENGINEERING FUNDAMENTALS FOR AERONAUTICAL ENGINEERS (4-2). An intensive course covering the fundamentals of Electrical Engineering including both circuits and electronic devices for students in Aeronautical Engineering. PREREQUISITES: MA 2047, MA 3130, MA 3173 or equivalent.

EE 2114 COMMUNICATIONS THEORY (4-0). In this introductory course the following concepts and their mathematical formulations are presented: power spectral density; matched filters; sampling; pulse encoding methods; frequency and time multiplexing; amplitude, frequency and phase modulation. In addition, a comparison of modulation methods is presented. PREREQUISITES: EE 2103 and EE 2212 or equivalent.

EE 2121 CIRCUIT FUNDAMENTALS (4-2). An introduction to basic electrical circuit theory for students in Avionics curriculum. The course topics include the circuit concept and circuit elements, power and energy; basic circuit laws and theorems; steady state solutions; state equations and trajectories. The course may be taught in the self instructed mode. PREREQUISITES: Differential and integral calculus (may be taken concurrently).

EE 2122 LINEAR SYSTEM FUNDAMENTALS (4-2). A continuation of EE 2121 for Avionic en-

gineers. Topics include Laplace transform; and time solutions network theroems and parameters; matrix methods; Fourier transform methods; convolution, signal flow graphs; simulation of linear systems on analog and digital computers. The course may be taught in the self-instructed mode. PREREQUISITES: EE 2121, differential equations and FORTRAN.

EE 2151 CIRCUIT EQUATIONS - A REVIEW (1-0). The circuit concept, signals, sources and circuit elements; Kirchhoff's laws; formulation of loop, nodal and state equations. PREREQUISITE: A proven background in electrical engineering, with consent of Instructor.

EE 2152 CIRCUIT ANALYSIS IN THE FREQUENCY DOMAIN - A REVIEW (1-0) Solution of circuit equations by the Laplace transform method, the s-domain and s-domain circuit equations; s-domain network functions; sinusoidal steady-state analysis; sinusoidal network functions; superposition, Thevenin's theorem and Norton's theorem. PREREQUISITE: EE 2151.

EE 2153 SOME TECHNIQUES OF NETWORK ANALYSIS - A REVIEW (1-0). Fourier series; frequency response; topology and matrix methods; two ports; circuit theorems, AC power. PREREQUISITE: EE 2152.

EE 2154 INTRODUCTION TO SYSTEMS - A REVIEW (1-0). The signal flow graph; state equation review; solution of state equations; initial condition response, natural modes and stability; forced response and transfer functional relationships between transfer functions, state equations time-domain convolution and signal flow graphs. PREREQUISITE: EE 2153.

EE 2155 ADDITIONAL TOPICS — CIRCUITS AND SYSTEMS (1-0). Topics chosen from among the following: modelling, discrete circuits and systems; Fourier integral (transfer); convolution in the time and frequency domains; stability. PREREQUISITE: EE 2154.

EE 2156 CIRCUITS & SYSTEMS LABORATORY (0-2). Laboratory projects to support EE 2151 thru EE 2155.

EE 2211-2212 ELECTRONICS ENGINEERING FUNDAMENTALS I-II (4-2) and (4-3). A general introduction to electronic devices and circuits; the electrical properties and charge flow mechanisms of semiconductor materials; properties of p-n junctions with emphasis on the role in diodes and bipolar transistors; application of diodes in circuits; static bipolar transistor models; MOS and junction FET's. Topics include analysis of linear amplifiers; determination of device parameters; design of biasing circuits; multistage amplifiers; properties of common amplifier configurations; feedback amplifiers; tuned amplifiers; and power amplifiers. PREREQUISITES: EE 2101 (may be concurrent) or equivalent.

EE 2213 ADVANCED REVIEW OF ELECTRONIC ENGINEERING FUNDAMENTALS (4-3). Review of semiconductor devices and circuit configurations; linear amplifiers and their analysis; multistage amplifiers and frequency response; power amplifiers and distortion effects, feedback amplifiers; stability effects and oscillation. PREREQUISITES: Degree in EE and permission of Instructor.

EE 2216 PULSE AND DIGITAL CIRCUITS (4-3). The topics studied include basic waveform characteristics and shaping techniques, wide-band linear amplifiers, characteristics of electronic switching devices, clipping, clamping and switching circuits, multivibrator and trigger circuits, time-based generators, logic circuits, counting and timing circuits. PREREQUISITES: EE 2212 or equivalent.

EE 2217 COMMUNICATION CIRCUITS (4-3). Electronic circuits used for the transmission and reception of analog and digital signals. Topics include oscillators, modulators, and demodulators, frequency converters, and special-purpose amplifiers. PREREQUISITES: EE 2216, EE 2114.

EE 2225 PULSE AND DIGITAL CIRCUITS (2-1). A course to prepare the student to understand pulse systems in radar and electromagnetic warfare. Included are wave-shaping and timing circuits, as well as basic logic circuits and concepts. Devices and circuits discussed include linear and non-linear wave shaping circuits using diodes and op-amps, gates, flip-flops, registers, counters, displays, decoders, multiplexers, A/D and D/A converters, sample-and-hold, and pulse stretchers. Laboratory experiments reinforce and extend concepts presented in the lectures. PREREQUISITE: EE 2721.

EE 2311 PRINCIPLES OF ENERGY CONVERSION (3-2). An introduction to the principles of energy conversion. Topics presented are thermoelectric, thermionic, photovoltaic, electrochemical and electromagnetic methods of energy conversion. PREREQUISITES: EE 2102, EE 2211, or equivalent, permission of Instructor.

EE 2411 CONTROL SYSTEMS (3-3). Introduction to the analysis and design of linear feedback control systems by means of s-plane and frequency response methods. Analysis using state variables for continuous and discrete systems; design using frequency and time domain performance indices is discussed. Laboratory work includes simulation using analog and digital computers; testing and evaluation of physical systems. PREREQUISITES: EE 2103 and CS 2700 or their equivalent.

EE 2418 CONTROL SYSTEMS (2-1). This course develops the basic tools of the control systems engineer. The applications to electronic warfare are emphasized in the examples and laboratory experiments. The dynamics for a radar control system, a missile seeker head tracking system and missiles are investigated. Basic topics are introduced such as signal flow graphs and system step and frequency response characteristics, and digital systems theory as used in radar tracking and command guided and semi-active homing missiles. PREREQUISITES: MA 3139, SECRET clearance and U.S. Citizenship.

EE 2421 INTRODUCTION TO COMMUNICATIONS TECHNOLOGY (4-2). The first of a sequence of five courses designed for the Telecommunications Specialist. An introduction is given to the basic elements of the communications system, followed by pertinent principles of electrical circuits and fundamentals of electronics devices. PREREQUISITE: A course in calculus.

EE 2422-2423 COMMUNICATIONS SYSTEMS I-II (4-3). A continuation of EE 2421. The topics covered are: the general analog communications systems with identification of subsystems; power conversion, oscillators, modulation and demodulation, special purpose circuits, elementary communication theory. A study of digital communication systems. The general concepts of digital signaling are covered, followed by a consideration of elementary switching and shaping circuits, logical processing and logic circuits, the digital computer as a communications sub-system, and elementary digital-data transmission theory. PREREQUISITE: EE 2421.

EE 2424 SIGNAL TRANSMISSION SYSTEMS (4-2). This course covers the elements of electrical energy transmission as applied to communications. The principles of electromagnetic waves are represented, guided waves on transmission lines and waveguides are studied. The radiated field in space, antennas and propagation are covered, and a representative system, such as a satellite communications system is studied. PREREQUISITE: EE 2423 (may be concurrent).

EE 2621 INTRODUCTION TO FIELDS AND WAVES (4-0). Static field theory is developed and applied to boundary value problems. Time-varying Maxwell equations are developed and solutions to the wave equations are presented. Additional topics include skin effect, reflection of waves and radiation. PREREQUISITE: EE 2103 or equivalent.

EE 2622 ELECTROMAGNETIC ENGINEERING (3-1). A continuation of EE 2621. Topics include transmission lines, waveguides and cavity resonators. Applications are presented in the laboratory. PREREQUISITE: EE 2621 or equivalent.

EE 2623 ELECTROMAGNETIC THEORY REVIEW (4-1). A comprehensive review of basic electromagnetic theory intended for those students having previous education in this subject area. This course will provide accelerated coverage of those topics in the basic undergraduate sequence EE 2621/2622. Topics include experimental laws and Maxwell's equations. Maxwell's equations are applied to problems in electrostatics and magnetostatics, plane wave propagation, TEM lines and cavities, TE and TM modes in rectangular and circular waveguides and cavities and radiation from elementary sources. Transient and state circuit properties of transmission lines are also covered. PREREQUISITES: Consent of Instructor; previous background in electromagnetic theory.

EE 2624 ELECTROMAGNETIC THEORY (4-1). This course covers the experimental laws of electromagnetic theory and the development of Maxwell's equations. Maxwell's equations are then utilized in the study of plane waves, transmission lines, wave guides, cavity resonators and elementary radiation. Laboratory experiments dealing with high frequency components and mea-

surements reinforce and extend the concepts presented in the lectures. PREREQUISITES: MA 2181 and EE 2721 or equivalent.

EE 2721 INTRODUCTION TO ELECTRONICS SYSTEMS (4-1). A first course in electronic systems for the ASW curriculum. Emphasis is on functional aspects of linear and non-linear operations on continuous and discrete signals. Topics include feedback amplifiers, linear circuits, reactive elements, non-linear elements, electronic logic and computation, and input/output and memory devices. PREREQUISITE: Mathematics through calculus; CO-REQUISITE: MA 2129.

EE 2810 DIGITAL MACHINES (3-3). Basic principles of digital system design with emphasis upon the organization and programming of simple computers. Elements of Boolean algebra and logic design. Storage organization and control. Input-output data flow. Relations of machine logic to program design. Laboratory sessions are devoted to study of computer logical elements, processing, storage, and I/O units. PREREQUISITE: CS 2700.

Upper Division or Graduate Courses

EE 3111 AVIONIC SYSTEMS (4-2). A course designed to provide as much background as possible in avionic systems for aeronautical engineers. Topics included are: radar principles, avionic computers, laser and infrared devices, sonar, navigation systems, systems engineering. PREREQUISITE: EE 2111.

EE 3118 COMMUNICATIONS SYSTEMS (4-2). The fourth in a sequence of courses designed for the Weapon Systems Technology curriculum. Modulation systems, analog and digital types; complete modulation systems incorporating pulse and pulse code schemes; noise in communication systems; error detection and correction; radar systems. PREREQUISITES: EE 2107, MA 3139 or equivalent.

EE 3215 MICROWAVE DEVICES (4-2). Electron tube and solid state microwave devices are studied. Klystrons, magnetrons, traveling wave tubes, microwave transistors, tunnel diodes, varactors, bulk effect, quantum electronic and other current devices are among those included. PREREQUISITES: EE 2212, EE 2622 (or their equivalent), or permission of Instructor.

EE 3263 INTEGRATED ELECTRONICS (3-3). Fabrication of bipolar and MOS ICs. Digital bipolar and MOS MSI and LSIs: multiplexers, decoders, memories, etc. Linear ICs: operational amplifiers, wave generators, phase locked loops, etc. Discussion of recent developments in ICs. PREREQUISITE: EE 2216.

EE 3311 ENERGY CONVERSION (3-2). A consideration and application of principles used in conversion of energy to the electric form. Devices utilizing these principles are analyzed and include thermoelectric, thermionic, electrochemical and others. A term paper based on library research in the energy conversion field is required. PREREQUISITES: EE 2102 or equivalent, EE 2211, permission of the Instructor.

EE 3312 ELECTROMAGNETIC MACHINES (3-4). The model oriented approach to the analysis of rotating machines and amplifiers is utilized to obtain their dynamic and steady state characteristics. DC motors, generators and control machines are analyzed. PREREQUISITE: EE 2103 or equivalent.

EE 3314 DISTRIBUTION AND CONVERSION OF ELECTRICAL ENERGY (3-2). An introduction to the steady state and dynamic operation of electric motors and generators. General transformer principles. A ship's power distribution system and its protection is considered. Polyphase circuits and symmetrical components are introduced as needed. PREREQUISITE: EE 2105.

EE 3410 CONTINUOUS AND DIGITAL CONTROL SYSTEMS (4-2). The third in a sequence of courses designed for the Weapon Systems Technology curriculum. Feedback; performance measures; root locus methods; systems with digital controllers; the matrix approach to analysis and design. PREREQUISITES: EE 2108, MA 3139 or equivalent.

EE 3413 FUNDAMENTALS OF AUTOMATIC CONTROL (3-3). A course in the fundamentals of automatic control theory and practice, primarily for nonelectrical engineering curricula. Topics include analysis and design of linear feedback control systems using frequency and time-domain techniques. Performance indices are discussed with application to the broad field of controls. Laboratory work includes computer simulation and test and evaluation of physical systems. PRE-

REQUISITES: MA 3121, EE 2105 or equivalent, or permission of Instructor.

EE 3420 ENGINEERING FUNDAMENTALS OF ELECTRO OPTICS (3-1). An introduction to elements of electro-optic systems for engineering students. Elements such as lasers, light emitting diodes, infrared sources and detectors are studied to characterize their operating parameters and limitations. The influence of other elements such as lens systems and properties of the propagation channel are also studied. PREREQUISITES: PH 2641 and EE 2212 or equivalent.

EE 3422 MODERN COMMUNICATIONS (3-2). A study of modern communications trends, with emphasis on theoretical study of current and proposed systems. The topics covered include multiplex systems, coding, and pseudo-random noise modulation systems. PREREQUISITE: EE 3571.

EE 3425 COMMUNICATION SYSTEMS ANALYSIS (3-3). The final course in the Communications Management sequence. The objective is to look at the overall Communications System with particular attention to system aspects. Some of the subjects considered are: underlying communication theory, multiplexing methods, evaluation and selection of systems, modern trends in systems. PREREQUISITE: EE 2424.

EE 3471 GUIDANCE AND NAVIGATION (3-2). A study of the systems involved in guidance and navigation. Topics include LORAN, OMEGA, NAVSAT, and inertial navigation systems. Various missiles and their guidance techniques are analyzed. PREREQUISITES: EE 2411 and EE 3631.

EE 3571 STOCHASTIC ANALYSIS OF SIGNALS (4-1). Fundamental concepts necessary for handling non-deterministic signals and noise in communication and control systems. Topics include properties of random variables, statistical averages, autocorrelation and power spectral density, transform relations, stationarity and ergodicity, noise models. The laboratory exercises illustrate the concepts and principles using real signals. PREREQUISITE: EE 2114.

EE 3575 SYSTEMS ASPECTS OF ELECTROMAGNETIC SIGNAL TRANSMISSIONS (4-0). This course is in the graduate sequence of the WS curriculum. It is designed to present a modern systems point of view on a graduate level to those students who do not elect to take an extensive EE sequence. Topics covered are: noise and its Statistical Analysis; Noise Passing Through Systems; Principles of Detection and Measurement; Factors Influencing Electromagnetic Transmission; Processing Signals for Maximum SNR; Theory of Detection; Topics in Extraction of Information; Applications of these Principles to Radar Systems. PREREQUISITES: Electromagnetics sequence through PH 2352.

EE 3625 ELECTROMAGNETIC RADIATION, SCATTERING AND PROPAGATION (4-2). This course covers the fundamentals of antennas used in the VLF through the microwave portion of the electromagnetic spectrum. Scattering and propagation in this part of the spectrum is also discussed, as are those elements of electromagnetic compatibility which relate to radiation. Laboratory exercises relating to pattern and impedance measurement, and use of computer programs further enhance the student's understanding of those concepts presented in the lectures. PREREQUISITE: EE 2624.

EE 3631 ELECTROMAGNETIC RADIATION AND COMPATIBILITY (4-2). This course covers wire and aperature antenna elements and arrays for communication and radar systems. Basic compatibility fundamentals are also discussed. While essentially stressing engineering, this course applies field theory concepts developed in earlier course to practical systems. PREREQUISITE: EE 2622 or equivalent.

EE 3652 MICROWAVE CIRCUITS AND MEASUREMENTS (3-2). A continuation of EE 2622. Waveguides and cavities are discussed in detail and perturbation theory is introduced. Other topics are selected from coupled lines, periodic circuits, strip line techniques, scattering parameters, and ferrities as well as topics from the current literature. Microwave measurement techniques will be presented in the laboratory. PREREQUISITE: EE 2622 or equivalent.

EE 3671 PROPAGATION (3-0). Properties of the earth and its atmosphere and their effect on radiowave propagation from ELF through millimeter wave-lengths. Topics include noise, scatter, coverage predictions and frequency selection. Use is made of engineering nomograms and computer

methods. PREREQUISITE: EE 2622 or equivalent.

EE 3714 INTRODUCTION TO SIGNALS AND NOISE (4-1). A course in the analysis of signals and noise. The topics include signal and noise parameters, linear systems response, modulation, sampling, correlation, and coding. The last week of the course requires participation in an ASW-related group project. This course is designed for the ASW curriculum. PREREQUISITES: EE 2721, PS 3411, MA 3139.

EE 3812 SWITCHING THEORY AND LOGIC DESIGN (3-2). Models for logic elements and networks. Equivalence and machine minimization. Threshold logic. Synthesis of combination and sequential networks. State assignment. Applications to digital machine design. Laboratory work is oriented around a project in logic network design. PREREQUISITE: EE 2810.

EE 3822 ENGINEERING APPLICATIONS OF COMPUTERS (3-3). Use of digital, analog, and hybrid computing machines in various application areas, e.g., systems design, parameter optimization, adaptive control, data acquisition and filtering, signal processing, biomedical instrumentation. Special techniques for real-time processing and simulation. Laboratory work is conducted in small groups and involves application studies using the various types of computers. PREREQUISITE: EE 2810.

Graduate Courses

EE 4121 ADVANCED NETWORK THEORY (3-2). Topology. Circuit formulation, nonlinear modeling, and computer solutions. Circuit sensitivity models. Concepts and tests for passivity, activity, causality, and stability. Driving point synthesis. Transfer function properties and synthesis. PREREQUISITES: EE 2103 or equivalent and EE 2211.

EE 4410 MATHEMATICAL MODELS AND SIMULATION FOR CONTROL SYSTEMS (3-2). Modeling of linear and nonlinear systems. Modeling concepts and techniques. Philosophy of model studies. Verification of the model and its parameters. Design studies using computer models. PREREQUISITE: EE 2411.

EE 4412 NONLINEAR AND DISCRETE SYSTEMS (3-3). Techniques for the analysis of nonlinear and discrete systems. Phase plane and describing function analysis. Laboratory work includes analog and digital simulation. PREREQUISITE: EE 2411.

EE 4414 STOCHASTIC CONTROL THEORY (2-2). Statistical and probabilistic concepts are applied to the development of optimal methods for estimation, prediction, and identification. These methods are applied to the stochastic control problem. PREREQUISITES: EE 2411 and EE 3571.

EE 4415 ALBEGRAIC METHODS IN CONTROL THEORY (4-0). This course treats advanced concepts in root-locus theory including graphical and analytical (algebraic) design of compensation. Extension is made to two-parameter analysis and design. The Mitrovic-Siljak relationships are developed, leading to the coefficient plane and parameter-plane methods. Stability analysis, adjustment, design and synthesis using parameter-plane methods are treated in detail. Extensions to multiparameter problems are discussed. PREREQUISITE: EE 2411.

EE 4416 TOPICS IN MODERN CONTROL THEORY (3-0). A course intended to acquaint the student with recent developments in control as found in the research publications of the profession. Topics are selected at the direction of the instructor and may include such subjects as Adaptive Systems, Digital and Hybrid Simulation, Finite State Automata, Learning Systems, Lyapunov Methods, Popov Stability, Sensitivity, etc. PREREQUISITE: Consent of the Instructor.

EE 4417 OPTIMAL CONTROL (4-0). The optimal control problem is treated using the calculus of variations. Pontryagin's maximum principle, and dynamic programming. PREREQUISITE: EE 2411.

EE 4418 SHIP CONTROL SYSTEMS (3-2). Theory of motion of ships. Basic ship control systems; steering, control roll stabilization, boiler control, loops, speed and propulsion controls. Sea states and their effects. Performance objectives and performance specifications. Models. Simulation studies. PREREQUISITE: EE 2411.

EE 4422 ELECTRO-OPTIC SYSTEMS ENGINEERING (3-1). Analysis and design of electro-optic systems such as laser communica-

tions, optical information processing, infared imaging and detection systems, laser-aided guidance. Emphasis is on the design of systems to meet specifications and analysis of existing systems to understand the design philosophy. PREREQUISITES: EE 3420 or EE 4421.

EE 4423 ELECTRO-OPTIC SYSTEMS AND COUNTERMEASURES (3-1). A study of military applications of electro-optic systems, IR and EO missile seekers, laser designators, optical surveillance, high energy laser systems, laser communications and laser radar. Emphasis is on system applications, countermeasures and counter-countermeasures. PREREQUISITES: PH 3271 or EE 4422 and SECRET clearance and U.S. Citizenship.

EE 4432 RADAR SYSTEMS (3-2). The principles of pulse radar systems are developed in classroom and laboratory exercises. Additional topics developed include the radar equation, doppler systems, automatic target-tracking systems, pulse compression, and multiple-unit steerable-array radars. PREREQUISITES: EE 3571 EE 3215, and EE 2622 or equivalent. This course is intended for students who do not have U.S. citizenship.

EE 4433 ADVANCED RADAR SYSTEMS (3-2). The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression, frequency-modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurement of radar cross section of targets. PREREQUISITES: EE 3215, EE 3571 (may be concurrent), SECRET Clearance and U.S. Citizenship.

EE 4434 MICROWAVE DEVICES AND RADAR (4-2). Those microwave devices most important in radar and in electronic warfare systems are studied, including magnetrons, traveling-wave tubes, and solid-state diodes. The radar range equation is developed. In addition to basic pulse radar, modern techniques are discussed including doppler systems, tracking radar, pulse compression, and electronically steerable array radars. Electromagnetic compatibility problems involving radar systems are considered. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with performance measurement methods, automatic tracking systems, pulse compression, and the measurement of radar cross section of targets. PREREQUISITES: EE 4716, EE 3625 (may be taken concurrently). SECRET clearance and U.S. Citizenship.

EE 4451 SONAR SYSTEMS ENGINEERING (4-2). A study of the theory and engineering practices pertaining to passive and active sonar systems. This study emphasizes the research and development of underwater acoustic surveillance systems. The objective of the course is to determine how the engineering design is conditioned by the characteristics of the transmission medium as well as the operational requirements. PREREQUISITES: PH 4454, EE 3571, EE 2212, U.S. Citizenship and SECRET clearance.

EE 4452 UNDERWATER ACOUSTIC SYSTEMS ENGINEERING (4-2). A study of the theory and engineering principles of underwater acoustics, communications, surveillance, and navigational systems. Emphasis is placed on the principles and problems common to all underwater acoustic systems, and the design tradeoffs that are available to the engineer. The laboratory periods are used for making engineering tests on existing systems and designing, building, and testing a system or subsystem of the student's own design. PREREQUISITES: EE 3571, EE 2212.

EE 4461 ADVANCED SYSTEMS ENGINEERING (3-1). An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. The class will be expected to participate in a group project involving a feasibility study of a proposed new system. PREREQUISITES: EE 3571, EE 2411.

EE 4473 MISSILE GUIDANCE SYSTEMS (3-1). Principles of inertial sensors and autonavigator systems. Radar and Infared trackers. Trajectory analysis. Steering logic.' Proportional navigation. Pursuit-evasion strategy. Control of ballistic and aerodynamic vehicles. Navigation and guidance in space. Laboratory work is concerned with testing of components and evaluation by computer simula-

tion of complete guidance system performance. PREREQUISITES: EE 4412, EE 4433, or equivalent, SECRET Clearance and U.S. Citizenship.

EE 4481 ELECTRONIC WARFARE TECHNIQUES AND SYSTEMS (3-3). Active and passive countermeasure techniques are considered, including signal representation, signal analysis. and signal interception. Important parameters of radar and communications systems are defined. Denial and deceptive jamming techniques are considered along with counter measure and counter counter-measure techniques. Signal intercept systems are treated. Acoustic, radio-frequency, infrared, and optical countermeasures are discussed. PREREQUISITES: EE 4433, U.S. Citizenship and SECRET Clearance.

EE 4482 SIGNALS INTELLIGENCE (SIGINT) SYSTEMS ENGINEERING (2-2). This course covers airborne, shipboard, and ground based intercept and direction finding system techniques used against simple and sophisticated electromagnetic radiation systems. Among the topics covered are current state of the art for wideband and directional antennas, wideband RF preamplifiers, scanning and chirping receivers, displays, recorders, pattern recognizers and signal analysis devices. The laboratory periods are largely devoted to the specification and block diagram of systems to handle specified SIGINT tasks. PREREQUISITES: EE 4481 or permission of Instructor. U.S. Citizenship and SECRET Clearance are required.

EE 4483 PRINCIPLES OF ELECTRONIC WARFARE (unclassified) (3-2). This course in electronic warfare is intended for students who do not have U.S. Citizenship. Particular attention is paid to the problems encountered in jamming radar systems, to the intelligence information needed for jamming, and to anti-jamming features for radars. Other topics include intercept receivers, intercept probability, direction finding, confusion reflectors, and infrared techniques. In the laboratory, basic principles are applied to jamming radar systems. PREREQUISITES: EE 4432 or EE 4433'.

EE 4484 ELECTRONIC WARFARE SYSTEMS (3-2). This course covers electronic warfare in that portion of the electromagnetic spectrum through the millimeter wavelength region. The infra red through electro-optic region is covered in a companion course, EE 4423. Electronic denial and deceptive countermeasures against fuses, communications, and various radar detection and tracking systems are discussed. Equations for required jammer gain and power output are developed. The characteristics of passive countermeasures are discussed. Other topics include anti-radiation missiles, counter-countermeasure circuits, target masking and modification, signal intercept, signal sorting, signal identification, and direction finding. Techniques are discussed in relation to U.S., allied, and communist block systems. Laboratory work reinforces the classroom discussions. PREREQUISITES: EE 4434, SECRET clearance, and U.S. Citizenship.

EE 4545 PRINCIPLES OF DIGITAL FILTERS (3-2). A course in the techniques and algorithms involved in the processing of discrete signals using the principles of digital filtering. Included is the approximation problem of converting frequency and time domain specifications into recursive and non-recursive filter algorithms, filter synthesis and realization, the discrete Fourier and other transformations, extension to multidimensional signal analysis, and image processing. Other topics included are error analysis, noise generation due to finite precision arithmetic, and limit cycles. Problems and exercises are derived from military applications and include filter design, realization, and testing. PREREQUISITE: EE 2114 or equivalent.

EE 4572 STATISTICAL COMMUNICATION THEORY (3-2). Advanced statistical methods applied to the analysis of signals and noise in communication systems, including applications to radar and sonar. Topics include the responses of linear and non-linear systems, error measures, optimal filters, decision schemes and parameter estimation, broadband concepts, and applications to analog and digital communications. The laboratory exercises feature real time signal processing methods. PREREQUISITE: EE 3571.

EE 4575 ADVANCED DIGITAL METHODS IN COMMUNICATION SYSTEMS (4-2). The intent of this course is to present the use of advanced digital methods (''state-of-the-art'') in present and proposed communication systems. An essential part of the course will be the student's laboratory experience with advanced hardware configured into subsystems and systems. Topics will include microcomputers, microprogramming (including devising and making programmed read-only-memories, PROM's) digital encoding and decod-

ing methods including interfacing and transmission, digital filters, display methods, advanced device technology including surface acoustic wave (SAW) methods, new logic families (CCD, ECL, I^2L), and various kinds of memory devices. PREREQUISITE: EE 3571.

EE 4581 INFORMATION THEORY (3-2). Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to coding and channel capacity. Effects of noise on information transmission. Coding methods for error control in digital communication systems. Selected applications of the theory to systems. PREREQUISITE: EE 4572.

EE 4591 COMMUNICATIONS SATELLITE SYSTEMS ENGINEERING (3-2). This course covers communication satellite systems including ground based, shipboard and airborne terminals as well as the satellite proper. Tradeoffs in orbits, modulation techniques, multipurpose systems, power sources, tie-in-techniques to standard communications including costs are covered. State of the art techniques in antennas, stabilizers, antennas, phase-locked-loops, and spread spectrum techniques are included. In addition, satellite tracking and siting problems are discussed. PREREQUISITE: EE 4572 (may be concurrent).

EE 4623 ADVANCED ELECTROMAGNETIC THEORY (3-2). This course will provide an introduction to mathematical techniques of importance in the solution of electromagnetic problems by numerical methods. Applications of Navy interest in the areas of antenna and microwave theory will be covered. These include radiation and scattering from wires and surfaces and wave propagation on structures used in microwave integrated circuitry. PREREQUISITE: Consent of Instructor.

EE 4716 SIGNAL PROCESSING SYSTEMS (4-1). A study of digital, analog, and hybrid signal processing systems for communications, echo ranging, and electronic surveillance. Examples from current and proposed military systems will be analyzed. This course is designed for the ASW curriculum. PREREQUISITE: EE 3714.

EE 4823 ADVANCED DIGITAL COMPUTER SYSTEMS (3-1). A course intended to acquaint the student with recent developments in digital systems as found in the research publications. Topics are selected at the discretion of the instructor and may include such subjects as: machine organization, computer graphics, man-machine interfaces, design automation, parallel processing, etc. An individually planned laboratory program is directed toward an experimental project involving state-of-the-art utilization of computer hardware or software. PREREQUISITE: EE 3812.

EE 4900 SPECIAL TOPICS IN ELECTRICAL ENGINEERING (2-0 to 5-0). Supervised study in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. Graded on a Pass/Fail basis only. PREREQUISITE: Consent of the Department Chairman.

ELECTRONIC WARFARE

The Electronic Warfare Academic Group has administrative responsibility for the academic content of the Electronic Warfare Systems Technology curriculum. Teaching in this multi-disciplinary program is carried out by faculty members attached to the following academic departments: Computer Science, Electrical Engineering, Mathematics, Meteorology, National Security Affairs, Operations Research, and Physics and Chemistry. Members of the Academic Group are:

DAVID BOYSEN HOISINGTON, Professor of Electronics; Chairman (1947)*; B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

EUGENE CASSON CRITTENDEN, JR., Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

JOHN NORVELL DYER, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

JEFFREY BRUCE KNORR, Associate Professor of Electrical Engineering (1970); B.S., Pennsylvania State Univ., 1963; M.S., 1964; Ph.D., Cornell Univ., 1970.

WILLIAM REESE, Professor of Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

NORMAN FLOYD SCHNEIDEWIND, Professor of Information Science and Computer Science (1971); B.S.E.E., Univ. of California at Berkeley, 1951; M.B.A., Univ. of Southern California, 1960; M.S.O.R. (ENGR), 1970; D.B.A., 1966.

ALAN ROBERT WASHBURN, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

1. The degree of Master of Science in Systems Technology will be awarded at the completion of a multidisciplinary program, Curriculum 595, satisfying the following degree requirements:

   a. The Master of Science in Systems Technology requires a minimum of 45 quarter hours of graduate level work of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included, and in three disciplines, a course at the 4000 level must be included.

   b. An approved sequence of at least three courses constituting advanced specialization in one area must be included.

   c. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

SYSTEMS TECHNOLOGY

ST 0002 SEMINAR (0-1). Special lectures and discussion of matters related to the EW program. PREREQUISITE: SECRET clearance.

ST 0810 THESIS RESEARCH/GROUP PROJECT (0-1). Students in the Systems Technology curricula will enroll in this course which consists of an individual thesis or a group project involving several students and faculty.

ST 3020 ELECTRONIC WARFARE COMPUTER APPLICATIONS (3-2). Application of digital and analog techniques to the recording, processing, display, and interpretation of electronic warfare signals and data. The computer is applied to the solution of electronic warfare problems such as signal identification, and to problems encountered in operational test and evaluation. PREREQUISITES: CS 3510, EE 4484, OS 3655, OS 3208, OS 4653 (may be taken concurrently).

ST 3350 SIGNAL INTELLIGENCE AND THE THREAT ENVIRONMENT (4-0). This course focuses on the current threat environment within which the U.S. Navy operates; U.S. signal intelligence capabilities for countering the threat; and the process for designing new U.S. countermeasure systems. The threat focus will specifically be on the Soviet Navy as the U.S. Navy's most formidable opponent in the foreseeable future. PREREQUISITES: SI clearance and U.S. Citizenship. Registration in EW curriculum #595 or consent of Instructor.

ST 4453 UNDERWATER SOUND, SYSTEMS, AND COUNTERMEASURES (3-2). A study of the principles of underwater sound propagation, and the design and operational characteristics of underwater sound systems. Emphasis is placed on various measures used to interfere with Sonar systems, and the techniques used to counter this interference. Topics studied include: sensor arrays, acoustic propagation, noise, acoustic quieting, signal processing, and examples of active and passive underwater acoustic systems, including acoustic countermeasures. PREREQUISITES: PH 2123, SECRET clearance, and U.S. Citizenship.

ENGINEERING ACOUSTICS

The academic character of programs in Engineering Acoustics is interdisciplinary, with courses drawn principally from the fields of electrical engineering and physics. Although broadly based, the emphasis is on those aspects of acoustics concerning propagation of sound in the oceans, on applications of underwater sound and on the electrical engineering of instrumentation for detection of underwater sounds. These programs are designed for students in the Underwater Acoustics Curriculum.

The academic aspects of the programs are the responsibility of a committee, chaired by O.B. Wilson, Jr., Professor of Physics, with G.S. Sackman, Associate Professor of Electrical Engineering, as a member.

DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science. Credit requirement for the Master of Science degree must be met by courses in addition to those used to satisfy this requirement.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

4. Approval of each program by the Engineering Acoustics Academic Committee.

DEPARTMENT OF MATHEMATICS

CARROLL ORVILLE WILDE, Professor of Mathematics; Chairman (1968)*; B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

CRAIG COMSTOCK, Professor of Mathematics (1970); B.E.P., Cornell Univ., 1956; M.S., Naval Postgraduate School, 1961; Ph.D., Harvard Univ., 1965.

DANIEL LEE DAVIS, Associate Professor of Mathematics (1971); B.S., Georgia Institute of Technology, 1965; Ph.D., California Institute of Technology, 1969.

FRANK DAVID FAULKNER, Distinguished Professor of Mathematics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942; Ph.D., Univ. of Michigan, 1969.

RICHARD HOMER FRANKE, Associate Professor of Mathematics (1970); B.S., Fort Hays Kansas State College, 1959; B.S., Univ. of Utah, 1961; Ph.D., 1970.

ROBERT EUGENE GASKELL, Professor of Mathematics (1966); A.B., Albion College, 1933; M.S., Univ. of Michigan, 1934; Ph.D., 1940.

TOKE JAYACHANDRAN, Associate Professor of Mathematics (1967); B.S., V.R. College, Nellore, India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

LADIS DANIEL KOVACH, Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.A., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

BROOKS JAVINS LOCKHART, Professor of Mathematics (1948); B.A., Marshall Univ., 1937; M.S., West Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943.

KENNETH ROBERT LUCAS, Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Univ. of Kansas, 1957.

HERMAN BERNHARD MARKS, Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

GEORGE WILLIAM MORRIS, Professor of Mathematics (1968); B.A., Southwestern Institute of Technology, 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., Univ. of California at Los Angeles, 1957.

IRA BERT RUSSAK, Associate Professor of Mathematics (1972); M.E., Stevens Institute of Technology, 1957; M.A., Univ. of California at Los Angeles, 1962; Ph.D., 1967.

ARTHUR LORING SCHOENSTADT, Associate Professor of Mathematics (1970); B.S., Rensselaer Polytechnic Institute, 1964; M.A., 1965; Ph.D., 1968.

ELMO JOSEPH STEWART, Professor of Mathematics (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Univ., 1953.

DONALD HERBERT TRAHAN, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

PETER CHENG-CHAO WANG, Associate Professor of Mathematics (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

MAURICE DEAN WEIR, Associate Professor of Mathematics (1969); B.A., Whitman College, 1961; M.S., Carnegie-Mellon Univ., 1963; D.A., 1970.

EMERITUS FACULTY

WILLARD EVAN BLEICK, Professor Emeritus (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

JOSEPH GIARRATANA, Professor Emeritus (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

CARL ADOLF HERING, Professor Emeritus (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

JOHN PHILIP PIERCE, Professor Emeritus (1948); B.S.E.E., Worcester Polytechnic Institute, 1931; M.S.E.E., Polytechnic Institute of Brooklyn, 1937.

FRANCIS McCONNELL PULLIAM, Professor Emeritus (1949); B.A., Univ. of Illinois, 1937; M.A., 1938; Ph.D., 1947.

CHARLES HENRY RAWLINS, JR., Professor Emeritus (1922); Ph.B., Dickinson College, 1910; M.A., 1913; Ph.D., Johns Hopkins Univ., 1916.

JAMES WOODROW WILSON, Professor Emeritus (1949); B.A., Stephen F. Austin State, 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S. in Ch.E., Texas A&M College, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers a Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. The program, and subsequent changes in the program, must be approved by the Departmental Chairman.

MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to the Master of Science degree with major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics. A student whose background does not satisfy this requirement may take course work to eliminate this deficiency. However, such courses cannot be counted toward satisfying the Departmental requirements for the degree of Master of Science.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 3.0 or greater in any major program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics.

4. The following topics are specifically included in any major program.
   a. 6 hours of Algebra
   b. 6 hours of Analysis

5. The main areas for thesis topics are
   a. Computer Science
   b. Differential Equations
   c. Fourier Analysis
   d. Functional Analysis
   e. Numerical Methods
   f. Optimal Control
   g. Probability and Statistics
   h. Tensor Analysis and Applications

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in

mathematics at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Mathematics Department. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MATHEMATICS

MA 0112 REFRESHER MATHEMATICS (5-5). Calculus review.

MA 0113 REFRESHER MATHEMATICS (5-5). Algebra review.

MA 0114 REFRESHER MATHEMATICS (5-5). Pre-calculus review.

MA 0125 LOGIC AND SET THEORY (5-0). An introduction to the elements of set theory and mathematical reasoning. Sets, Venn Diagrams, truth tables, quantifiers, logical reasoning. Functions, relations, partitions and equivalence relations, 1-1 correspondence. (Paradoxes of set theory, axiom of choice.) PREREQUISITE: None.

MA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MA 1021 PRECALCULUS MATHEMATICS (4-0). Brief review of algebraic fundamentals. Algebra of complex numbers, quadratic equations. Systems of equations. Trigonometric functions of the general angle. Identities. Solution of right triangles. Elements of the theory of equations. Introduction to analytic geometry. PREREQUISITES: None.

MA 1100 CALCULUS AND VECTOR ANALYSIS (5-2). Functions of one variable, limits, derivatives, continuity, indefinite and definite integrals, transcendental functions. Taylor's theorem, vectors in two and three dimensions, functions of several variables, partial derivatives, multiple integration. PREREQUISITE: A previous course in calculus.

MA 1115-1116 CALCULUS I-II (5-0). Introduction to plane analytic geometry, functions of one variable, limits, continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, polar coordinates, vector algebra in three dimensions. Vector calculus in three dimensions, functions of several variables, double and simple integrals, vector field theory, infinite series. PREREQUISITE: Some previous work in calculus.

MA 1119 SELECTED CALCULUS TOPICS REVIEW (2-1). Functions, limits, continuity, differentiation of functions of one variable and several variables. Implicit functions, parametric equations, optimization. Definite, indefinite and multiple integrals. Sequences and series, series representation of functions, Euler's formula. PREREQUISITE: A previous course in calculus.

MA 1120-1121 CALCULUS AND ANALYTIC GEOMETRY I-II (5-2). Introduction to plane analytic geometry, functions of one variable, limits, continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, elementary vector algebra, vector differentiation. Polar coordinates, vector algebra and vector calculus in three dimensional space, functions of several variables, double and triple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1021.

MA 1131 INTRODUCTION TO CALCULUS (1-0). A review of the real number system and topics in analytic geometry. PREREQUISITE: college algebra.

MA 1132 LOGIC, FUNCTIONS AND LIMITS (1-0). Elementary logic and mathematical induction, functions, continuity and limits. PREREQUISITE: MA 1131 or equivalent.

MA 1133 DIFFERENTIAL CALCULUS (1-0). Slope, derivative, chain rule, implicit differentiation and the differential. PREREQUISITE: MA 1132 or equivalent.

MA 1134 APPLICATIONS OF DIFFERENTIAL

CALCULUS (1-0). Graphing, optimization problems, rate and simple harmonic motion. PREREQUISITE: MA 1133 or equivalent.

MA 1135 INVERSE FUNCTIONS (1-0). Logarithmic and inverse trigonometric functions intermediate value theorem; hyperbolic functions. PREREQUISITE: MA 1133 or equivalent.

MA 1136 THE DEFINITE INTEGRAL (1-0). Anti-derivatives, areas, volumes of solids of revolution, integration between limits. PREREQUISITE: MA 1135 or equivalent.

MA 1137 APPLICATIONS OF THE DEFINITE INTEGRAL (1-0). Arc length, center of mass and centroids. Trapezoidal and Simpson's rules. Fundamental theorem of the integral calculus. PREREQUISITE: MA 1136 or equivalent.

MA 1138 VECTORS IN THE PLANE (1-0). Parametric equations. Paths and curvature in the plane. Geometric principles. Vectors in the plane. PREREQUISITE: MA 1137 or equivalent.

MA 1139 DIFFERENTIAL CALCULUS OF SEVERAL VARIABLES (1-0). Partial differentiation. Coordinates and graphs in space. Planes and tangent planes. The chain rule, implicit functions. Gradient and directional derivative. PREREQUISITE: MA 1138 or equivalent.

MA 1140 MULTIPLE INTEGRATION (1-0). Vectors in space; paths, gradients and arc lengths. Double and triple integrals and applications. Cylindrical and spherical coordinates. PREREQUISITE: MA 1139 or equivalent.

MA 1150 INFINITE SERIES (1-0). Infinite series and sequences. Tests for convergence of positive series. Manipulating infinite series. The Cauchy product of two series. Power series. Derivative or integral of a power series. Taylor series and forms of the remainder. Solving differential equations. PREREQUISITE: MA 1120 or equivalent.

Upper Division Courses

MA 2025 LOGIC, SETS AND FUNCTIONS (4-0). Propositional logic, elements of set theory, relations, functions and partitions. An introduction to theorem proving techniques, including mathematical induction, in the context of basic mathematical systems. PREREQUISITE: None.

MA 2040 MATRIX ALGEBRA (2-0). Linear equations, systems of linear equations, determinants, matrices and vectors, addition and multiplication of matrices, inverse of a matrix, partitioned matrices, vector spaces and subspaces, rank of a matrix. This course is designed primarily for students in management. PREREQUISITE: College algebra.

MA 2042 LINEAR ALGEBRA (4-0). Systems of linear equations, matrices, and determinants. Finite dimensional vector spaces, linear dependence, basis, dimension, inner products, orthogonalization. Linear transformations, rank and nullity, change of basis, linear functionals, orthogonal transformations, quadratic forms, symmetric matrices, diagonalization, eigenvalues and eigenvectors. PREREQUISITE: MA 2109 or MA 1116.

MA 2045 COMPUTATIONAL MATRIX ALGEBRA (3-0). Systems of linear algebraic equations. Matrix algebra and determinants. Numerical methods in linear algebra. Vector spaces. Rank, Inverse by Gauss' method. Characteristic equations, roots and vectors — numerical methods. PREREQUISITE: None.

MA 2048 LINEAR ALGEBRA AND VECTOR ANALYSIS (5-0). Algebra of matrices. Determinants. Elementary matrices, rank of matrix and inverse of a matrix. Linear vector spaces, subspaces, linear dependence and independence, basis and dimension. Systems of homogeneous and nonhomogeneous linear equations and their solutions. Eigenvalues and vectors in R^2 and R^3. Calculus of these vectors. Del operator, directional derivative, gradient, divergence and curl with applications. Vector integration, line integrals, surface and volume integrals. Green's, Stokes' and the Divergence Theorem. PREREQUISITE: MA 1100 or equivalent.

MA 2109 TOPICS IN CALCULUS (5-0). A selection of miscellaneous topics such as differential equations, vector analysis in three space, three-dimensional differential and integral calculus, infinite series. PREREQUISITE: Differential and integral calculus.

MA 2110 MULTIVARIABLE CALCULUS (4-0). Integrated with linear algebra. Functions of several variables, continuous transformations, jacobians, chain rule, implicit function theorem, inverse function theorem, extrema, Lagrange multiplier

technique, curvilinear coordinates. PREREQUISITE: MA 1100 or equivalent, MA 2042 or equivalent concurrently.

MA 2121 DIFFERENTIAL EQUATIONS (4-0). Ordinary differential equations: homogeneous and nonhomogeneous equations, linear independence of solutions, linear and non-linear equations, power series solutions, systems of differential equations, applications. PREREQUISITE: MA 1100 or equivalent, MA 2045 or equivalent concurrently.

MA 2129 ORDINARY DIFFERENTIAL EQUATIONS AND LAPLACE TRANSFORMS (2-1). First order ordinary differential equations, second order equations with constant coefficients, application, LaPlace Transforms. PREREQUISITE: Differential and integral calculus.

MA 2161 INTRODUCTION TO MATHEMATICAL PHYSICS (5-0). An introduction to the techniques used in solving problems in classical field theories. Vector and scalar fields are studied. Potential fields for fluid flow using curvilinear coordinates. Vector field theory. Analytic functions of a complex variable. Residue theory with application to Fourier and Laplace transforms. Conformal mapping. PREREQUISITE: MA 1110 and MA 2121 (the latter may be taken concurrently).

MA 2172 COMPLEX VARIABLES (4-0). Analytic functions, integration and series representations. Residue theory and applications applied to ordinary and partial differential equations; convolution theorems. PREREQUISITE: MA 2121.

MA 2181 VECTOR CALCULUS (2-1). Differentiation and integration of vector functions. The del operator and related concepts. Green's theorem, Stokes' theorem, divergence theorem. Interpretations and applications. PREREQUISITE: Calculus and vector algebra.

MA 2232 NUMERICAL METHODS (3-1). Error propagation. Evaluation of functions. Non-linear equations. Linear algebra for computers. Interpolation. Least squares approximation. Numerical integration. Ordinary differential equations. PREREQUISITE: MA 2121 and CS 0110 or equivalent.

MA 2300 MATHEMATICS FOR MANAGEMENT (5-0). This course is designed to provide a mathematical basis for modern managerial tools and techniques. It includes elements of differential and integral calculus, sequences and series and an introduction to matrix algebra. PREREQUISITE: College algebra.

MA 2305-2306 CALCULUS I-II (3-0), (2-0). A two course sequence in calculus designed primarily for students in Administrative Science. Brief review of algebra; differential calculus of power functions, logarithmic functions and exponential functions; multivariable calculus, maxima and minima with and without constraints. Integral calculus of power functions, logarithmic functions and exponential functions. Applications will be from the field of economics and management. PREREQUISITE: College algebra.

MA 2310-2311 MATHEMATICS FOR NAVAL INTELLIGENCE I-II (5-3) and (5-2). A review of linear, logarithmic, sinusoidal and exponential functions, with graphical emphasis; differentiation and integration, with both analytical and numerical procedures, continuation to include introductory treatments of Fourier analysis; the Fourier integral, spectral analysis, differential equations and the Laplace transformation. Descriptive statistics and data presentation, discrete probability and the binomial and Poisson distributions, continuous probability, the normal distribution and the central limit theorem, hypothesis testing, estimation and correlation, small samples. Students' t-distribution, the Chi-square distribution. Single and multiple regression, computation, data processing and analysis. PREREQUISITE: College algebra and trigonometry.

MA 2400 INTRODUCTION TO VECTORS, MATRICES AND VECTOR CALCULUS (3-0). The algebra of vectors and matrices. Systems of linear equations, determinants; eigenvalues. Directional derivative, gradient, divergence, curl; line, surface and volume integrals; integral theorems; applications. PREREQUISITE: Differential and integral calculus.

MA 2401 INTRODUCTION TO DIFFERENTIAL EQUATIONS AND COMPLEX FUNCTIONS (4-1). Ordinary differential equations including series solutions and Laplace transforms; Fourier series and partial differential equations; complex

analytic functions. PREREQUISITE: Differential and integral calculus.

Upper Division or Graduate Courses

MA 3026 TOPICS IN DISCRETE MATHEMATICS (4-0). Review of mathematical induction. Elements of number theory; divisibility; congruences and prime numbers. Generating functions and combinatorial problems. Elements of graph theory. PREREQUISITE: MA 2025.

MA 3046-3047 LINEAR ALGEBRA I-II (3-0). Special types of matrices; orthogonal reduction of a real symmetric matrix to diagonal form; quadratic forms and reductions to expressions involving only squares of the variables; applications to maxima and minima; Lambda matrices and related topics; Cayley-Hamilton theorem. Reduced characteristic function; canonical forms, idempotent and nilpotent matrices; solutions to matrix polynomial equations; functions of a square matrix; applications such as to differential equations, stability criteria. PREREQUISITE: MA 2045.

MA 3130 DIFFERENTIAL EQUATIONS (4-0). Review of linear ordinary differential equations. Separation of variables for partial differential equations. Fourier Series and orthogonal functions. Series solutions and special functions. Boundary value problems in two and three dimensions. PREREQUISITE: MA 1100, MA 2400 and ordinary differential equations.

MA 3132 PARTIAL DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (4-0). Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3139 FOURIER ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS (4-0). Solution of the one-, two-, and three-dimensional wave equations by separation of variables and characteristics; ray propagation; Fourier analysis applied to ordinary and partial differential equations; convolution therorems. PREREQUISITE: MA 2129.

MA 3173 COMPLEX VARIABLES AND LAPLACE TRANSFORMS (4-0). Continuation of MA 3130. Complex variables, contour integration, residue theory, conformal mapping; applications to ordinary and partial differential equations including Laplace transforms and their complex inversion. PREREQUISITE: MA 3130.

MA 3181 VECTOR ANALYSIS (3-0). Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1100 or equivalent.

MA 3185 TENSOR ANALYSIS (3-0). Definition of a tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The co-variant derivative and its application to geodesics. The Reimann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3232 NUMERICAL ANALYSIS (3-2). Solution of nonlinear equations, zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations, eigenvalues. Numerical solutions of ordinary differential equations. Analysis of computational errors. PREREQUISITE: MA 2121 or equivalent (may be taken concurrently) and FORTRAN programming.

MA 3243 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS (4-1). Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. The implicit alternating direction method. Approximations at irregular boundaries. Elliptic equations. The Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. A term project involving the solution of a suitably difficult boundary value problem is required, PREREQUISITE: MA 3132, CS 2700 or equivalent.

MA 3362 ORBITAL MECHANICS (3-0). Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. Perturbations. PREREQUISITE: A course in dynamics.

MA 3560 MODERN APPLIED ALGEBRA (3-0). An introductory course in the techniques and tools of abstract algebra with special emphasis on appli-

cations to coding theory, radar and communications systems, and computer science. Elements of set theory, equivalence relations and partitions. Semigroups, groups, subgroups and homomorphisms. Rings, ideals and fields. Directed graphs and lattices. Applications may vary. PREREQUISITE: Consent of Instructor.

MA 3565 MODERN ALGEBRA I (3-0). An advanced course in the subject of abstract algebra. Semigroups, groups, subgroups, normal subgroups. Groups acting on sets, operator groups. The Jordan-Holder Theorem, solvable groups. The Krull Schmidt Theorem. PREREQUISITE: MA 3560 or consent of Instructor.

MA 3605-3606 FUNDAMENTALS OF ANALYSIS I-II (3-0). Elements of set theory, the real number system, and the usual topology of En; properties of continuous functions; differential of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorem, extremum problems). Functions of bounded variation and theory of Reimann-Stieltjes integration, multiple and iterated integrals, convergence theorems for sequences and series of functions. PREREQUISITE: Consent of Instructor.

MA 3610 INTRODUCTION TO GENERAL TOPOLOGY (3-0). Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures. Tychonoff product theorem, Alexandroff and Stone-Cech compactification. PREREQUISITE: MA 3605.

MA 3675-3676 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I-II (3-0). Selected topics from the theory of functions of a real variable; complex functions, power series, laurent series. Singularities of complex functions; residues and contour integration; zeros of analytic functions, factors of and infinite product representation for analytic functions; maximum modulus theorems for analytic and harmonic functions; conformal mapping. PREREQUISITE: Consent of Instructor.

MA 3730 THEORY OF NUMERICAL COMPUTATION (3-0). Analysis of computational methods used for the solution of problems from the areas of algebraic equations, polynomial approximation, numerical differentiation and integration, and numerical solution of ordinary differential equations. PREREQUISITE: Consent of Instructor.

Graduate Courses

MA 4237 ADVANCED TOPICS IN NUMERICAL ANALYSIS (4-0). The subject matter will vary according to the abilities and interest of those enrolled. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

MA 4393 TOPICS IN APPLIED MATHEMATICS (3-0). A selection of topics in applied mathematics. The course content varies. Credit may be granted for taking this course more than once. PREREQUISITE: Consent of Instructor.

MA 4501 TOPICS IN FOUNDATIONS OF MATHEMATICS (3-0). A selection of topics in foundations of mathematics. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

MA 4566 MODERN ALGEBRA II (3-0). A continuation of MA 3565. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynominal rings. Modules and ideals. Noetherian rings, Field extension and Galois theory. PREREQUISITE: MA 3565.

MA 4593 TOPICS IN ALGEBRA (3-0). A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

MA 4610 TOPOLOGY OF DYNAMICAL SYSTEMS (3-0). Dynamical systems, trajectories, limiting sets, recursive concepts, dispersive concepts, stability theory. PREREQUISITES: MA 2121 and either MA 3605 or MA 3610.

MA 4611 CALCULUS OF VARIATIONS (3-0). Bliss differential methods, Euler equations, Weierstrass-maximum principle, Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and applications to engineering and control problems. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4620 THEORY OF ORDINARY DIFFERENTIAL EQUATIONS (3-0). Introduction to the modern theory of ordinary differential equations. Systems of equations. Theoretical and constructive methods of solutions. PREREQUISITE: Consent of Instructor.

MA 4622-4623 PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS I-II (3-0). Linear operators, generalized functions and Hilbert spaces; solutions of partial differential equations by eigenfunctions; variational techniques and their applications to eigenfunctions; integral equations, Laplace, Fourier and other transforms, including their inversion in the complex plane as applied to partial differential equations; method of characteristics for hyperbolic equation. PREREQUISITES: MA 3132 or equivalent and MA 2172 or equivalent.

MA 4635-4636 FUNCTIONS OF REAL VARIABLES I-II (3-0). Axiomatic set theory, development of the real numbers, semi-continuous functions, absolutely continuous functions, functions of bounded variation; classical Lebesgue measure and integration theory, convergence theorems and Lp spaces. Abstract measure and integration theory, signed measures, Radon-Nikodym theorem; Lebesgue decomposition and product measure; Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 3606.

MA 4637 INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). An introduction to Banach and Hilbert spaces, including open mapping-closed graph theorem, weak and weak star topologies, spectral theorems for compact Hermitian operators. Hermitian bounded and normal bounded operators. PREREQUISITE: MA 4636.

MA 4672 INTEGRAL TRANSFORMS (3-0). The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2172.

MA 4693 TOPICS IN ANALYSIS (3-0). A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4872 TOPICS IN CALCULUS OF VARIATIONS (3-0). Recent development in the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applications to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: spectral variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121, MA 3046 and computer programming or Consent of Instructor.

DEPARTMENT OF MECHANICAL ENGINEERING

ALLEN EUGENE FUHS, Distinguished Professor of Mechanical Engineering; Chairman (1966)*; B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

JOHN EDISON BROCK, Professor of Mechanical Engineering (1954); B.S.M.E., Purdue Univ., 1938; M.S.E., 1941; Ph.D., Univ. of Minnesota, 1950.

GILLES CANTIN, Professor of Mechanical Engineering (1960); B.A. Sc., Ecole Polytechnique at Montreal, 1950; M.Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

THOMAS EDWARD COOPER, Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Berkeley, 1966; M.S.M.E., 1967; Ph.D., 1970.

CLARENCE JIMMY GARRISON, Associate Professor of Mechanical Engineering (1970); B.S.M.E., Univ. of Nebraska, 1960; M.S.M.E., 1962; Ph.D., Univ. of Washington, 1968.

THOMAS MICHAEL HOULIHAN, Associate Professor of Mechanical Engineering (1969); B.M.E., Manhattan College, 1961; Ph.D., Syracuse Univ., 1968.

MATTHEW DENNIS KELLEHER, Associate Professor of Mechanical Engineering (1967); B.S. Univ. of Notre Dame, 1961; M.S.M.E., 1963, Ph.D., 1966.

TERRY ROBERT McNELLEY, Assistant Professor of Materials Science (1976); B.S.M.E., Purdue Univ., 1967; Ph.D., Stanford Univ., 1973.

PAUL JAMES MARTO, Professor of Mechanical Engineering (1967); B.S., Univ. of Notre Dame, 1961; M.S., in Nuc. Engr., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

ROBERT EUGENE NEWTON, Professor of Mechanical Engineering (1951); B.S.M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

DONG HUU NGUYEN, Associate Professor of Mechanical Engineering (1969); B.S.M.E., Purdue Univ., 1960; M.S. in Nuc. Eng., 1961; Ph.D., Univ. of California at Berkeley, 1965.

ROBERT HARRY NUNN, Associate Professor of Mechanical Engineering (1968); B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

ARTHUR JEFFERY PERKINS, Associate Professor of Materials Science (1972); B.S., Drexel Institute of Technology, 1965; M.S., Case Institute of Technology, 1967; Ph.D. in Metallurgy, Case Western Reserve University, 1969.

PAUL FRANCIS PUCCI, Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S.M.E., 1950; Ph.D., Stanford Univ., 1955.

DAVID SALINAS, Associate Professor of Mechanical Engineering (1970); B.S., Univ. of California at Los Angeles, 1959; M.S., 1962; Ph.D., 1968.

TURGUT SARPKAYA, Distinguished Professor of Mechanical Engineering (1967); M.S.M.E., Tech. Univ. of Istanbul, 1951; Ph.D., Univ. of Iowa, 1954.

GARRET NIEL VANDERPLAATS, Adjunct Research Professor of Mechanical Engineering (1976); B.S., Arizona State Univ., 1967; M.S., 1968; Ph.D., Case Western Reserve Univ., 1971.

EMERITUS FACULTY

ROY WALTERS PROWELL, Professor Emeritus (1946); B.S. in I.E., Lehigh Univ., 1936; M.S.M.E., Univ. of Pittsburgh, 1943.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

1. *Undergraduate Preparation.* A candidate shall have completed work equivalent to the Bachelor of Science requirements of this department.

2. *Approved Curriculum.* The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, approved curriculum must satisfy the requirements in paragraphs 3 and 4.

3. *Required Courses.* The Master of Science degree in Mechanical Engineering requires at least 32 quarter hours of graduate level credits in Mechanical Engineering and Materials and Science, at least 10 of which must be at the 4000 level. In addition, at least 8 quarter hours of graduate credit must be earned outside of Mechanical Engineering and Materials Science.

4. *Thesis.* An acceptable thesis is required for the Master of Science in Mechanical Engineering degree. An acceptable thesis for the Mechanical Engineering degree may also be accepted as meeting the thesis requirement for the Master's degree. Approval of the thesis topic must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineering Department for consultation in the development of a program of research.

MASTER OF SCIENCE IN APPLIED SCIENCE

1. Students with acceptable academic backgrounds may enter a program leading to the degree of Master of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in mechanical engineering at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Mechanical Engineering Department. A total of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

THE PROGRAM LEADING TO THE DEGREE OF MECHANICAL ENGINEER

A graduate student with a superior academic record may enter a program leading to the degree Mechanical Engineer. A candidate is normally selected during his second year of residence.

The candidate must take all courses in a curriculum approved by the Chairman of the Department of Mechanical Engineering. At minimum, approved curriculum must satisfy the requirements stated in paragraphs 3 and 4 below.

The Mechanical Engineer degree requires at least 60 quarter hours of graduate level credits in Mechanical Engineering and Materials Science, and in addition, at least 12 quarter hours of graduate level credits must be earned outside of Mechanical Engineering and Materials Science. At least 30 of the above required graduate level credits must be at the 4000 level.

An acceptable thesis is required for the Mechanical Engineer degree. Approval of the thesis program must be obtained from the Chairman of the Mechanical Engineering Department. An advisor will be appointed by the Chairman of the Mechanical Engineering Department for consultation in

the development of a program of study and a program of research.

THE PROGRAM LEADING TO THE DEGREE OF DOCTOR OF PHILOSOPHY

Graduate officer students may, upon satisfactory completion of eleven quarters of academic work, apply for the program leading to the degree of Doctor of Philosophy. Normally, this program requires the equivalent of at least one academic year being spent at the Naval Postgraduate School. A Doctoral Committee is appointed for the student which has the full responsibility for providing a program of study suitable to the needs of the student and the requirements for award of the degree.

The Department of Mechanical Engineering is authorized to offer doctorate degrees in the areas of mechanics and deformable bodies, fluid mechanics, and heat transfer.

A dissertation advisor is appointed by the Department Chairman who, together with the Doctoral Committee, is responsible for the development of a program of study and research. Approval of the programs must be obtained from the Academic Council.

Admission to the Ph.D. program is also available to qualified civilian employees of the United States government.

MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to the extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes machinery for the investigation of dynamic and static problems in engineering mechanics; a completely equipped materials science laboratory; a scanning electron microscope; a water tunnel, and a wave channel; facilities for experimentation with air flows from incompressible through supersonic velocities; equipment for instruction in thermal transport phenomena; a laboratory for demonstrating nuclear engineering principles; and a fluid power control and fluidics laboratory. Experimentation is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

MECHANICAL ENGINEERING

ME/MS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

ME 0951 SEMINAR (0-1). Lectures on subjects of current interest are presented by NPS faculty and invited experts from other universities and government and industrial activities.

Upper Division Courses

ME 2101 ENGINEERING THERMODYNAMICS (4-1). A comprehensive coverage of the fundamental concepts of classical thermodynamics, with insight toward microscopic phenomena. The laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis. Gas-vapor mixtures. Combustion and dissociation. PREREQUISITE: MA 1100.

ME 2201 INTRODUCTION TO FLUID MECHANICS (3-2). Properties of fluids. Fluid statics, stability of submerged bodies. Mass, momentum, and energy considerations in steady flows. Dynamic similitude and dimensional analysis. Fluid measurement and control. Basic effects of fluid friction. Emphasis on naval engineering applications and problem solving. PREREQUISITE: ME 2502.

ME 2410 MECHANICAL ENGINEERING LAB I (2-3). Fundamentals of mechanical measurement systems, structured laboratory experiments using resistance strain gages, pressure transducers, temperature, flow and velocity measurement devices. PREREQUISITES: ME 2101, ME 2201, and ME 2601, any of which may be taken concurrently. Graded on Pass/Fail basis only.

ME 2501 STATICS (3-0). Forces and moments, particles and rigid bodies in equilibrium. Simple structures, friction, first moments and centroids. PREREQUISITE: MA 1100 (may be concurrent).

ME 2502 DYNAMICS (4-0). Kinematics, Newton's laws and d'Alembert's principle work and energy, impulse and momentum, plane motion of a rigid body. PREREQUISITE: ME 2501.

ME 2510 STATICS AND DYNAMICS (5-2). A course combining the content of ME 2501 and ME

2502. PREREQUISITE: MA 1100 (may be concurrent).

ME 2601 MECHANICS OF SOLIDS I (3-2). Stress, strain, Hooke's law. Elementary stress and deformation analysis for shafts, beams and columns. Supporting laboratory work. PREREQUISITES: ME 2501, or ME 2510, and MA 1100.

Upper Division or Graduate Courses

ME 3001 SURVEY OF ENGINEERING (3-0). A comprehensive survey of engineering history and development. This is an elective course for non-M.E. majors.

ME 3002 PRINCIPLES OF NAVAL ENGINEERING (3-0). An introduction to the principles of engineering machinery and equipment aboard ship. Primary emphasis is placed on helping the student acquire an overall view of shipboard engineering plants and an understanding of basic considerations that underlie the design of machinery and equipment. An elective course for non-M.E. majors.

ME 3003 ENERGY AND THE ENVIRONMENT (3-0). Principles of energy technology. Supply and demand. Survey of resources including coal, oil, gas, and uranium fuels. Solar energy utilization. Energy conversion schemes. Conservation efforts in the Navy. Effect of energy utilization upon the environment. This is an elective course for non-M.E. majors.

ME 3150 HEAT TRANSFER (4-2). Elementary treatment of the principles of Heat Transfer application to problems in Mechanical Engineering. Steady and unsteady conduction. Principles of forced and natural convection. Thermal radiation. Boiling. Condensation. Heat exchanger analysis. Use of the thermal circuit analog numerical and graphical techniques. Selected laboratory experiments. PREREQUISITES: ME 2101, ME 2201, MA 3132 (may be taken concurrently).

ME 3201 APPLIED MECHANICS OF NAVAL AND OCEAN STRUCTURES I (3-2). Equations of fluid motion. Stream and potential functions. Resistance in unsteady flow. Drag, lift and inertia coefficients. Water waves. Marine propulsion. Propellers and current propulsion devices. Cavitation and cavitation damage. Fundamentals of compressible flows and effect of compressibility in liquids and gases. PREREQUISITES: ME 2201 and ME 3521.

ME 3250 FLUID MACHINERY (3-2). Fundamental characteristics of reciprocating power pumps, direct-acting steam pumps, pump valves, rotary pumps, pistonless pumps, centrifugal and axial pumps, air compressors and compressor accessories, turbomachines, and centrifugal and axial fans. Efficiency of fluid machinery. Application to practical fluid-handling systems and naval operations of pumps, compressors, fans, and turbomachinery. Installation, operation, and maintenance of fluid machinery. PREREQUISITES: ME 2101 and ME 2201.

ME 3301 NUCLEAR POWER SYSTEMS (5-0). Brief review of atomic, nuclear structures, and nuclear reactions. Neutron interactions with matter: cross sections, slowing down and diffusion of neutrons. Fundamentals of nuclear reactor analysis: neutronic and thermal aspects in core design. Principal reactor types. Naval applications of nuclear energy.

ME 3315 NUCLEAR MEASUREMENTS LAB (1-4). Principles of radiation detection. The use of various health physics instruments and radiation detectors; gas-filled, scintillation, crystal and foil detectors; calibration of detectors. Experiments in neutron physics: determination of neutron Fermi age and diffusion length. Neutron fast and thermal fluxes mapping by various detectors. Determination of flux perturbation by local absorption. Gamma ray spectrometry; pulse height analyzer. PREREQUISITES: ME 2410, ME 3301 or equivalent, ME 3341.

ME 3430 MECHANICAL ENGINEERING LAB II (1-3). A project-oriented continuation of mechanical measurement systems. Application of measurement techniques using group projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations and nuclear radiation detection. PREREQUISITES: ME 2410, ME 3150, ME 3521, and ME 3611. Graded on Pass/Fail basis only.

ME 3440 ENGINEERING SYSTEMS ANALYSIS (4-0). Classification of engineering problems. Classical and numerical techniques for solving equilibrium, eigenvalue, and propagation problems for discrete and continuous systems. Applications to heat transfer fluids, and solids prob-

lems. PREREQUISITES: ME 2101, ME 2201, ME 3521, and ME 3611.

ME 3450 THERMODYNAMICS OF MARINE POWER SYSTEMS (3-2). Current applications of thermodynamic principles applied to marine power systems. Detailed analyses of vapor and gas power cycles. The characteristics of engines, compressors, and turbines. Refrigeration, air conditioning and cryogenic systems. PREREQUISITE: ME 2101.

ME 3521 MECHANICAL VIBRATION (3-2). Free and forced vibration of discrete linear systems. Vibration isolation and suppression. Vibration of bars, shafts, and beams. Supporting laboratory work. PREREQUISITES: ME 2502, or ME 2510, ME 2601, and MA 2401 (may be concurrent).

ME 3611 MECHANICS OF SOLIDS II (4-0). Constitutive laws for linear elastic solids. Fundamentals of the theory of elasticity. Applications to beams. Stability of simple structures. Torsion of members with non-circular cross section. Elements of plate and shell behavior. PREREQUISITES: ME 2502, or ME 2510, ME 2601, and MA 2401 (may be concurrent).

ME 3711 DESIGN OF MACHINE ELEMENTS (3-2). The design of representative machine elements with consideration given to materials, tolerances, variable loads and stress concentrations. PREREQUISITE: ME 3611.

ME 3712 DESIGN OF MACHINERY (2-4). Dynamic analysis and design of machinery with consideration given to manufacturing processes. PREREQUISITES: ME 3711 and ME 3521.

ME 3801 FLUID POWER CONTROL (3-2). Operation and analysis of control valves and actuators. Hydraulic power elements. Steady state and dynamic performance of electro-hydraulic servovalves and servomechanisms. Design criteria for fluid power controls. PREREQUISITE: ME 2201 (may be taken concurrently).

Graduate Courses

ME 4161 CONDUCTION AND RADIATION HEAT TRANSFER (4-0). Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Variational methods. Mechanical Engineering applications. Black body radiation; radiation from real surfaces; radiation exchange between finite surfaces. The network method, radiation through participating media. PREREQUISITE: ME 3150.

ME 4162 CONVECTION HEAT TRANSFER (4-0). Fundamental principles of forced and free convection. Dimensionless correlations. Heat transfer during phase changes. Combined conduction, convection and radiation heat transfer systems. Heat exchanger analysis with Mechanical Engineering applications. PREREQUISITES: ME 3150, ME 4220 (may be taken concurrently).

ME 4211 NAVAL HYDRODYNAMICS (4-0). Equations of motion. Vorticity and circulation. Solutions to flow about two- and three-dimensional bodies. Conformal transformations and hydrofoils. Approximate methods of flow analysis. Free surface hydrodynamics with Naval Engineering applications. PREREQUISITE: ME 3201, or consent of Instructor.

ME 4220 VISCOUS FLOW (4-0). Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Low Reynolds number flows. Development of the boundary layer equations. Similarity variables, numerical and integral techniques. Separation, boundary layer control, compressibility effects. Time-dependent boundary layers. Stability, transition, and turbulence. Nature of turbulence, phenomenological theories, calculation of turbulent flows. PREREQUISITES: ME 2101 and ME 2201.

ME 4230 ADVANCED TOPICS IN FLUID DYNAMICS AND HEAT TRANSFER (4-0). Topics selected in accordance with the research interests of students and staff. Advanced and analytical methods. Surveys of current Mechanical Engineering technologies. Extensions to the theories of fluid flow and heat transfer. PREREQUISITES: ME 4161, ME 4162, and MA 2172 (may be taken concurrently), or consent of Instructor.

ME 4240 APPLIED MECHANICS OF NAVAL AND OCEAN STRUCTURES II (3-2). Nonlinear surface waves and fluid-structure interactions. Free-streamline analysis of cavities, planing, and gliding. Hydro-ballistics, water-exit and entry studies. Quiet torpedo technology. Topics selected

in accordance with the current interests of the students and the Navy. PREREQUISITES: ME 3201, ME 4211, and ME 4220.

ME 4311-ME 4312 NUCLEAR REACTOR ANALYSIS I-II (4-0). Neutron cross-sections. Resonance phenomena and Doppler effect. The fission process. The slowing down and diffusion of neutrons. Criticality analysis of homogenous and heterogeneous reactors. Reflected reactors. Multigroup diffusion method. Fundamentals of neutron transport theory. Reactor kinetics and control. Change in reactivity during reactor lifetime. Application of perturbation theory to reactivity calculations. PREREQUISITE: ME 3301 or equivalent.

ME 4321 REACTOR ENGINEERING PRINCIPLES AND DESIGN (4-2). Reactor heat generation and removal. Thermal stress analysis. Nuclear fuel cycle. Change in reactivity during core lifetime. Overriding of fission product poisoning. Principal types of reactor systems. The synthesis of reactor physics, heat transfer and hydraulics, properties of materials and safety requirements in reactor design. Student group design project. PREREQUISITES: ME 3301 and ME 3150.

ME 4410 MARINE GAS TURBINES (3-2). Thermodynamic analyses of gas turbine cycle variations (e.g., simple, regenerated, combined). Internal aerodynamics of compressor and turbine design. Combustor design. Lubrication and fuel systems. Operational control and instrumentation. Inlet, exhaust, and silencing systems. Repair and maintenance. Propulsion of hydrofoil, surface effect, and conventional surface ships. Auxiliary power generation. Waste heat utilization. Naval research and development. PREREQUISITE: ME 3450 or consent of Instructor.

ME 4504 NAVAL WEAPONS I: GUN AND MISSILE ENGINEERING (3-2). Gun internal ballistics: gun propellant combustion; one-dimensional, time-dependent model of gas flow. External ballistics: flat-earth trajectory equations with aerodynamic forces and with and without projectile propulsion. Estimation of CEP. Damage by blast in both air and water. Hydraulic ram. Missile performance: rocket, aerodynamics, guidance and control. Discussion of guns vs missiles.

ME 4505 NAVAL WEAPONS II: LASER TECHNOLOGY (3-2). Types of lasers according to pumping mechanisms, laser performance, propagation of laser beams, pointing and tracking, acquisition and handoff, damage mechanisms, aero-optics, optical systems for lasers, advantages and limitations of high energy lasers, and military applications. PREREQUISITE: Consent of Instructor. (May also be taught as AE 4505)

ME 4512 ADVANCED DYNAMICS (4-0). Three-dimensional kinematics. The inertia tensor. Dyadic-vector formulation of dynamical equations. Topics of special interest. PREREQUISITE: ME 3521.

ME 4522 VIBRATION, NOISE, AND SHOCK (4-0). Matrix analysis of many degree of freedom systems. Discrete models of continuous systems. Transfer matrices. Applications to shipboard vibration and noise control. Shock response analysis. PREREQUISITE: ME 3521.

ME 4612 ADVANCED MECHANICS OF SOLIDS (4-0). Additional advanced topics. PREREQUISITES: MA 3132 or equivalent and ME 3611.

ME 4613 FINITE ELEMENT METHODS (4-0). Systematic construction of line, surface, and volume elements for continuous systems. Applications to structural mechanics, heat transfer, fluid flow. PREREQUISITE: ME 3611.

ME 4620 THEORY OF CONTINUOUS MEDIA (4-0). Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Applications to elasticity and fluid dynamics. PREREQUISITES: ME 2201, ME 3611, and MA 2401.

ME 4721-ME 4722 MARINE VEHICLE DESIGN I-II (2-4). Various categories of marine vehicles are described; this includes single hull, multiple hull, submarine, surface effect, wing-in-ground effect and hydrofoil vehicles. A category of marine vehicle is selected to fulfill a stated mission. A vehicle configuration and specification of major components which satisfies mission requirements is sought. Consideration is given to all major facets of marine vehicle synthesis including structures, hull forces, propulsion, electronics, armament, crew, etc. PREREQUISITE: ME 3711.

ME 4902 ADVANCED STUDY IN MECHANICAL ENGINEERING (2-0 to 6-0). Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member.

May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman. Graded on Pass/Fail basis only.

MATERIALS

Upper Division Courses

MS 2201 ENGINEERING MATERIALS (3-2). Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. The effects of atomic structure, crystal structure, and microstructure on properties of structural materials are emphasized. Crystalline defects, deformation processes, strengthening mechanisms, brittle fracture, phase equilibria, heat treatment, and microstructural control are discussed with reference to practical examples. The course aims at providing the Naval Engineering student with the vocabulary and conceptual understanding necessary for further study or for communicating with materials experts. PREREQUISITE: Elementary courses in physics and chemistry.

MS 2218 ELEMENTS OF ENGINEERING MATERIALS (3-2). Prerequisite, course content, and development parallels MS 2201 with emphasis on Aeronautical and Aerospace applications.

Upper Division or Graduate Courses

MS 3201 MATERIALS SCIENCE AND ENGINEERING (3-2). Intended as a first course in materials for students who have had an undergraduate survey course in materials (such as MS 2201), or who have a good background in chemistry, thermodynamics, and physics. Fundamental principles of materials science are presented with particular emphasis on mechanical behavior. Topics covered include atomic structure, crystal structure, microstructure, crystalline defects, deformation processes, strengthening mechanisms, fracture, and phase transformations. PREREQUISITE: Undergraduate course in materials, and/or courses in chemistry, thermodynamics, and physics.

MS 3202 PROPERTIES, PROBLEMS, AND FAILURES OF STRUCTURAL MATERIALS (3-2). Topics of interest to the Naval, Aero, or Weapons engineer are emphasized through case studies of actual failures. The cause(s) of each failure are presented, and the necessary background material to fully understand the phenomena is then provided in each case. Failures due to fatigue, brittle fracture, corrosion, and fabrication deficiencies are among those discussed. Selection of materials and modern methods of materials analysis are treated. PREREQUISITE: MS 2201 or equivalent, or permission of Instructor.

MS 3206 IMPERFECTIONS IN CRYSTALLINE SOLIDS (3-0). The effects of crystalline defects on the physical and mechanical behavior of solids are discussed. This course examines in moderate detail those microstructural features which have a major impact on materials development, fabrication, and utilization. Example topics are point defects in electronics, materials, strain-aging phenomena, the role of stacking faults in material failure, and subgrain strengthening. PREREQUISITE: MS 2201 or equivalent.

MS 3304 CORROSION (3-2). Presents the basic chemical, electrochemical, mechanical, and metalurgical factors which influence the corrosion, oxidation, and deterioration of materials. Discusses standard methods of corrosion control, such as cathodic protection coatings, cladding, alloy selection, and inhibitors; special problems encountered in unfamiliar environments. PREREQUISITE: MS 2201 or equivalent.

MS 3401 MICROSCOPY (3-2). Electron microscopy and other sophisticated techniques are emphasized in a coverage of modern methods of microscopic observation. Techniques covered include scanning electron microscopy, transmission electron microscopy, conventional microprobe analysis, field ion microscopy, and polarized light, stereo, interference, phase contrast, and holographic light optical methods. Course and lab will simultaneously cover both theory and practice, including specimen preparation, instrument design and operation, and applications. PREREQUISITE: Consent of Instructor.

Graduate Courses

MS 4215 PHASE TRANSFORMATION (3-2). Structural changes which commonly occur in materials by various mechanisms are considered. Solidification, precipitation, recrystallization, and martensitic transformations are emphasized, both in principle and in regard to their technological importance. Principles of nucleation and growth, diffusion and kinetics are presented and their rele-

vance to practical heat treating and fabrication processes are considered. PREREQUISITE: MS 2201 or equivalent.

MS 4302 SPECIAL TOPICS IN MATERIALS SCIENCE (Hours by arrangement.) Independent study of advanced subjects not regularly offered. PREREQUISITE: Consent of Instructor.

MS 4305 MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS (3-0). The materials used in electrical and electronic applications are discussed, including ferro-magnetic and ferri-magnetic materials, semi-conductors, insulators, dielectrics, and piezo-electric and ferrolectric crystals. The electronic, crystallographic and thermodynamic principles controlling these materials are discussed and the heat treatments, compositions, and methods of fabrication of commercial materials are emphasized. PREREQUISITE: MS 2201 or equivalent.

MS 4312 ADVANCED MATERIALS (4-0). The course is structured to provide a vehicle for the study of materials pertinent to a specific area of environmental utilization or design. Example categories are marine materials, nuclear materials, elevated-temperature materials, aircraft alloys, materials for energy conversion. Topics discussed may include material failures, materials selection, testing, and new concepts in materials engineering. Course scope is decided by mutual agreement of students and Instructor. PREREQUISITE: MS 2201, MS 3202, or equivalent.

MS 4811 MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS (3-2). The response of structural materials to mechanical stress is discussed with emphasis on plastic deformation in metals. Topics include mechanisms of high-temperature deformation, fatigue, and fracture. New concepts allowing development of materials to circumvent these failure mechanisms are treated. PREREQUISITES: MS 3202 or permission of Instructor.

DEPARTMENT OF METEOROLOGY

GEORGE JOSEPH HALTINER, Distinguished Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

CHIH-PEI CHANG, Associate Professor of Meteorology (1972); B.S., National Taiwan Univ., 1966; Ph.D., Univ. of Washington, 1972.

KENNETH LA VERN DAVIDSON, Associate Professor of Meteorology (1970); B.S., Univ. of Minnesota, 1962; M.S., Univ. of Michigan, 1966; Ph.D., 1970.

RUSSELL LEONARD ELSBERRY, Associate Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

ROBERT LEE HANEY, Associate Professor of Meteorology (1970); A.B., George Washington Univ. 1964; Ph.D., Univ. of California at Los Angeles, 1971.

ROBERT JOSEPH RENARD, Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

WILLEM van der BIJL, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ. Utrecht, 1952.

FORREST ROGER WILLIAMS, CDR, U.S. Navy; Assistant Professor of Meteorology (1974); B.S., Naval Academy, 1956; M.S., Naval Postgraduate School, 1962; M.S., Massachusetts Institute of Technology, 1972.

ROGER TERRY WILLIAMS, Professor of Meteorology (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

EMERITUS FACULTY

WILLIAM DWIGHT DUTHIE, Distinguished Professor Emeritus (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

FRANK LIONEL MARTIN, Professor Emeritus (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN METEOROLOGY OR METEOROLOGY AND OCEANOGRAPHY

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.

b. Thirty-five quarter hours of graduate meteorology courses of which 15 hours must be in the 4000 series.

c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, must be included in these 35 hours.

d. An acceptable thesis.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. **Direct** entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry,

differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

Indirect entry into the program is possible for persons lacking a baccalaureate degree in meteorology or oceanography through the oceanography curriculum (440). Minimal entrance requirements here include differential and integral calculus, and a year each of college physics and chemistry.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR 4323 and 10 quarter hours in the 4000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

b. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

The Ph.D. is offered in the Department of Meteorology in the following areas of study; numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems, and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, examination in both the major and a minor field, and languages. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology also requires a preliminary examination in order, to show evidence of acceptability as a doctoral student.

Prospective students should consult with the Chairman of the Department of Meteorology for further information and guidance regarding doctoral programs.

METEOROLOGICAL LABORATORIES

In addition to the standard synoptic laboratories, NPS meteorological facilities include most instruments in present-day use for observing the atmosphere as well as equipment for copying weather data, analyses and forecasts emanating from the National Weather Service. Similar information is received from Numerical Weather Central in Monterey. Rawinsonde and wiresonde equipment, an air inversion meter, an APT receiver for readout of weather satellite data and micrometeorologically instrumented masts on the Research Vessel R/V ACANIA are utilized by faculty and students in the Meteorology and Oceanography Programs.

METEOROLOGY

MR 0110 APPLICATIONS SEMINAR (1-0). Presentation of D.o.D. related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students and visiting authorities. PREREQUISITE: Enrollment in an Environmental Sciences curriculum.

MR 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

MR 2200 DESCRIPTIVE METEOROLOGY (4-0). A general course which includes basic instruments, the physical laws governing atmospheric processes, the composition and vertical structure of the atmosphere, physical processes, cyclones and anticyclones, air masses, fronts tropical disturbances, general circulation and observations from satellites. PREREQUISITE: Department approval.

MR 2210 MARINE METEOROLOGY (4-3). An introductory course that treats the composition and structure of the atmosphere, thermodynamical processes, forces and related small- and large-scale motions, air masses, fronts, severe storms, solar and terrestrial radiation and weather forecasting. Laboratory periods are devoted to exercises illustrating lecture material including weather-map analysis over oceanic areas. PREREQUISITE: PH 1011 or equivalent; Calculus (concurrently).

MR 2413 METEOROLOGY FOR ANTISUBMARINE WARFARE (3-0). A general course in meteorology for the ASW curriculum. Atmospheric stability and EM wave propagation are related to vertical distributions of temperature and moisture; precipitation, clouds and wind are related to synoptic systems; boundary fluxes are related to momentum exchange from the free atmosphere; changes in the mixed layer depth are related to boundary fluxes. PREREQUISITES: Differential and integral calculus and OC 2265.

MR 2416 METEOROLOGY FOR ELECTRONIC WARFARE (2-0). A survey of environmental factors affecting the propagation and attenuation of electromagnetic (EM) and optical (EO) waves in the atmosphere; vertical distributions of temperature and moisture in standard atmosphere; synoptic conditions associated with anomalous propagation of electromagnetic waves; regions and layers associated with high level turbulance intensities affecting optical wave propagation; climatologies of high altitude ionized regions affecting propagation of EM waves greater than 10 meter wavelength. PREREQUISITES: MA 3139 or PS 3411.

MR 2520 CLIMATOLOGY AND STATISTICS (3-1). Discussion of climate classifications, changes and controls. Climates of areas important to the Navy. Basic statistical quantities (mean, standard deviation, correlation and regression) are introduced and their role in climatology demonstrated. PREREQUISITE: MR 2210.

Upper Division or Graduate Courses

MR 3150 GEOPHYSICAL RANDOM PROCESSES (3-1). Estimation and decision theory. Spatial and temporal sampling of geophysical data. Harmonic analysis and orthogonal functions. Time series analysis. PREREQUISITE: MR 2520.

MR 3212 POLAR METEOROLOGY/OCEANOGRAPHY (3-1). Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Geology and geophysics. PREREQUISITES: MR 3230, OC 3221.

MR 3220 METEOROLOGICAL ANALYSIS (3-0). Techniques of evaluation, interpretation and analysis of pressure, wind temperature and moisture data, including weather satellite observations, with emphasis on the low and middle troposphere. Synoptic models of extratropical vortices, waves and frontal systems, with emphasis on three-dimensional space structure and time continuity. Introduction to analysis in the high troposphere and low stratosphere. PREREQUISITES: MR 2210 or equivalent; MR 3321 or OC 4321, or consent of the Instructor.

MR 3225 METEOROLOGICAL ANALYSIS LABORATORY (0-6). Applications of concepts considered in MR 3220 with emphasis on the analysis of the low and middle troposphere, especially surface and 500 mb charts and associated vertical cross sections. PREREQUISITES: MR 3220 concurrently; MR 2210 or equivalent.

MR 3230 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY (4-0). An analytic and synoptic interpretation of tropospheric and stratospheric systems with emphasis on the middle and high altitude aspects of extratropical cyclones, jet streams and fronts, and related dynamical properties. PREREQUISITES: MR 3220, MR 4322 concurrently.

MR 3235 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY LABORATORY (0-8). Practice in synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships and application to forecast problems. PREREQUISITES: MR 3225, MR 3230 concurrently.

MR 3240 OPERATIONAL ENVIRONMENTAL PRODUCTS (3-4). Meteorological and oceanographical products available to the operating fleet from Fleet Numerical Weather Central/Fleet Weather Centrals and other sources are described and applied to the diagnosis and prognosis of tactical environmental parameters for both current and historical situations. PREREQUISITES: MR 2210 and OC 3221.

MR 3250 TROPICAL METEOROLOGY (3-0). Structure and development of tropical cyclones; observations of synoptic-scale wave disturbances, cloud clusters, upper tropospheric systems, the intertropical convergence zone and monsoon circulations; tropical scale analysis and energetics. PREREQUISITES: MR 4322, MR 3220.

MR 3252 TROPICAL METEOROLOGY/ LABORATORY (3-4). Same as MR 3250 plus laboratory sessions on streamline, isotach and contour (isobaric) analyses and forecasting of tropical systems, with emphasis on tropical cyclones and the use of meteorological satellite observations. PREREQUISITES: MR 3220/5 and MR 4322.

MR 3260 PROGNOSTIC CHARTS AND FORECASTING WEATHER ELEMENTS (3-0). Subjective and objective methods of atmospheric prognosis and techniques for forecasting operationally-important weather elements from surface to 10 mb. Interpretation, use and systematic errors of computer-generated products. PREREQUISITES: MR 3230; MR 4323 or consent of Instructor.

MR 3262 PROGNOSTIC CHARTS AND FORECASTING WEATHER ELEMENTS/LABORATORY (3-4). Same as MR 3260 plus laboratory sessions on the application of lecture material. Also practice in weather briefing, including diagnosis and forecasting of current weather situations using weather satellite observations and National Meteorological Center and Fleet Numerical Weather Central products. PREREQUISITES: MR 3230, MR 4323 or consent of Instructor.

MR 3321 AIR-OCEAN FLUID DYNAMICS (4-0). The hydrodynamical equations for a rotating fluid. Forces, kinematics, simple balanced flows, barotropy, baroclinicity, vertical shear; various vertical coordinates. Friction and boundary layers, introduction to scale analysis. Vorticity and divergence equations. PREREQUISITES: MA 2048, MA 2121 (may be concurrent), or equivalent.

MR 3420 GEOPHYSICAL THERMODYNAMICS (4-0). The physical variables; properties of gases, water and moist air; equations of state and the laws of thermodynamics applied to the atmosphere and oceans, entropy, adiabatic processes and potential temperatures; meteorological thermodynamic diagrams; geopotential and hydrostatic equilibrium, static stability criteria and phenomena. PREREQUISITES: Calculus, MR 2200 or equivalent, or consent of Instructor.

MR 3421 CLOUD PHYSICS (3-0). Basic principles of cloud and precipitation physics and application to weather modification. Selected topics in atmospheric pollution. PREREQUISITE: MR 3420.

MR 3512 HEAT TRANSFER PROCESSES (4-0). Monochromatic intensity and flux from black bodies; other properties of black bodies. The flux of terrestrial radiation crossing an arbitrary level in an atmosphere consisting both of water vapor and carbon dioxide. Terrestrial flux-divergence as a cooling effect in the atmosphere. Solar insolation at the outer boundary of the atmosphere and at the earth; parameterization of solar attenuation processes in the atmosphere. The mean heat balance of the earth and atmosphere. Net radiative energy as a driving mechanism for the general circulation. PREREQUISITE: MR 3420 or consent of Instructor.

MR 3820 PRINCIPLES OF MEASUREMENT (3-2). The application of the basic principles of mechanics, heat, electricity, sound and optics to meteorological instrumentation employed by the Navy with special emphasis on upper-air and satellite developments. Design and operation of oceanographic instruments; recording of oceanographic observations. PREREQUISITE: MA 2121 or equivalent.

Graduate Courses

MR 4241 MESOSCALE METEOROLOGY (3-0). Description and physical understanding of subsynoptic scale weather systems and their relation to the synoptic-scale environment. Applications to short-range and local-area forecasting utilizing satellite and numerical-model products relevant to mesoscale weather phenomena. PREREQUISITES: MR 3230/5; MR 4323, or MR 4322 with consent of Instructor.

MR 4242 ADVANCED TROPICAL METEOROLOGY (3-0). Equatorial wave theory; stratospheric wave motions and quasi-biennial oscillations; tropospheric disturbances; energy sources and instabilities; boundary layer and cumulus convection parameterization; monsoon circulations and their interactions with other scales; and selected topics in dynamics and thermodynamics of tropical flows. PREREQUISITE: Consent of Instructor.

MR 4250 GENERAL CIRCULATION OF THE ATMOSPHERE AND OCEANS (3-0). Selected topics on the general circulation of the atmosphere (e.g., heat, momentum and moisture fluxes; energetics) and ocean (e.g., linear and nonlinear theories of the wind-driven ocean circulation, non-

linear thermocline theories, mesoscale eddies, mixed-layer theories), coupled ocean-atmosphere general circulation models. PREREQUISITE: Consent of Instructor.

MR 4322 DYNAMIC METEOROLOGY (4-0). Scale analysis, perturbation method; solutions of equations of motion for sound, gravity, and synoptic waves, filtering; baroclinic and barotropic instability; geostrophic adjustment. PREREQUISITES: MR 3420, MR 3321, MA 3132.

MR 4323 NUMERICAL AIR AND OCEAN MODELING (4-3). Numerical models of meteorological and oceanographic phenomena. Finite difference techniques for solving elliptic and hyperbolic equations, linear and nonlinear computational instability. Filtered and primitive equation prediction models. Energetics. Sigma coordinate. Objective analysis, initialization and four-dimensional data assimilation as time permits. PREREQUISITES: MR 4322, MA 3232.

MR 4324 ADVANCED NUMERICAL WEATHER PREDICTION (3-0). Initialization, boundary conditions, finite-difference schemes, stability and convergence; sensible, latent, and radiative heat transfer, simulation of sub-grid scale processes such as convection and friction; general circulation models, spectral methods. PREREQUISITES: MR 4323 or consent of Instructor.

MR 4331 ADVANCED GEOPHYSICAL FLUID DYNAMICS I (3-0). Advanced topics in the dynamics of the atmosphere and the oceans including scale analysis; geostrophic adjustment; dispersion, and barotropic and baroclinic instabilities. PREREQUISITE: Consent of Instructor.

MR 4332 ADVANCED GEOPHYSICAL FLUID DYNAMICS II (3-0). Energetics of unstable disturbances; energy cascade; boundary layer analysis with application to the Ekman layer and to the frictional and the nonlinear ocean boundary currents; finite amplitude effects. PREREQUISITE: Consent of Instructor.

MR 4413 AIR/SEA INTERACTION (4-0). Consequences of momentum, heat and moisture exchange between the atmosphere and the ocean. Concepts in turbulence and similarity theory for stationary turbulent regimes adjacent to the air/sea interface. The oceanic well-mixed layer. Mutual atmosphere and ocean response times and synoptic-scale energy exchanges. PREREQUISITE: MR 4322 or consent of Instructor.

MR 4415 ATMOSPHERIC TURBULENCE (3-0). Approaches for defining the structure of the turbulent atmospheric boundary layer. Review of statistical descriptions of atmospheric turbulence; averaging, moments, joint moments, spectral representation. Equations for a turbulent regime in a stratified, shear flow. Scaling parameters and similarity theories for surface layer profiles, spectra; Kolmogorov hypotheses, Monin-Obukhov stability length. Measurement of atmospheric turbulence. Examination of observed spectra and scales of atmospheric turbulence. PREREQUISITES: MR 4322 and MR 3150, or consent of Instructor.

MR 4416 ATMOSPHERIC FACTORS IN ELECTROMAGNETIC PROPAGATION (3-0). Principles of radar, laser and sound propagation in the atmosphere. Sensing from satellites, effects of atmosphere on propagation: refraction, scattering, attenuation, superrefraction, ducting, etc. Detection of atmospheric phenomena. PREREQUISITES: MR 3230; MR 3512, or consent of Instructor.

MR 4800 ADVANCED ANALYSIS AND PREDICTION (3-0). Selected topics in geophysical fluid dynamics, advanced diagnostic and prognostic techniques including modeling, remote sensing, etc. The course may be repeated for credit as topics change. PREREQUISITE: Consent of Department Chairman.

MR 4900 SEMINAR IN METEOROLOGY (2-0). Students present results of thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper. Graded on Pass/Fail basis only.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

PATRICK JOHNSTON PARKER, Professor of Economics; Chairman (1974)*; M.B.A., Univ. of Chicago, 1955.

JOHN WILLIAM AMOS, II, Assistant Professor of Political Science (1970); B.A., Occidental College, 1957; M.A., Univ. of California at Berkeley, 1962; Ph.D., 1972.

DAVID PATRICK BURKE, Lt. Col., USAF, Assistant Professor of Political Science (1976); A.B., Univ. of California at Berkeley, 1956; M.A., San Francisco State College, 1963; M.P.A., Harvard Univ., 1969; Ph.D., 1975.

CLAUDE ALBERT BUSS, Professor of Political Science and History (1976); B.A., Washington Missionary College, 1922; M.A., Susquehanna Univ., 1924; Ph.D., Univ. of Pennsylvania, 1927.

DONALD CHARLES DANIEL, Assistant Professor of Political Science (1975); A.B., Holy Cross College, 1966; Ph.D., Georgetown Univ., 1971.

BOYD FRANCIS HUFF, Professor of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California at Berkeley, 1955.

STEPHEN JURIKA, JR., Adjunct Professor of Political Science (1975); B.S., U.S. Naval Academy, 1933; M.A., George Washington Univ., 1957; Ph.D., Stanford Univ., 1962.

EDWARD JOHN LAURANCE, Assistant Professor of Political Science (1972); B.S., U.S. Military Academy, 1960; M.A., Temple Univ., 1970; Ph.D., Univ. of Pennsylvania, 1973.

KURT LONDON, Adjunct Professor of International Affairs (1976); Ph.D., Univ. of Berlin, Heidelberg, Germany, 1928.

RALPH HARRY MAGNUS, Assistant Professor of National Security Affairs (1976); A.B., Univ. of California at Berkeley, 1958; M.A., 1966; Ph.D., 1971.

WILLIAM REESE, Professor of National Security Affairs and Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

RONALD GRAHAM SHERWIN, Assistant Professor of Political Science (1975); B.A., California State Univ. at Long Beach, 1965; M.A., Univ. of Southern California, 1967; Ph.D., 1972.

KAMIL TAHA SAID, Associate Professor of National Security Affairs (1975); B.A., Colorado State College, 1937; M.A., San Jose State College, 1967.

RUSSEL HENRY STOLFI, Associate Professor of History (1966); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

FRANK MICHAEL TETI, Associate Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; M.P.A., Syracuse Univ., 1972; Ph.D., 1966.

JIRI VALENTA, Assistant Professor of National Security Affairs (1976); Ing. Pol. E.K., Prague School of Economics, 1968; Ph.D., John Hopkins Univ., 1975.

PETER CHENG-CHAO WANG, Associate Professor of Mathematics and National Security Affairs (1970); B.A., Pacific Lutheran Univ., 1961; M.A., Wayne State Univ., 1962; Ph.D., 1966.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF ARTS IN NATIONAL SECURITY AFFAIRS

1. The entrance requirements for this program are

a baccalaureate degree earned with above average academic performance. Applicants must demonstrate their aptitude for the specific curriculum option concerned, through either the Graduate Record Examination or the completion of undergraduate courses which meet the prerequisite requirements for the courses offered in the option. Such applicants must have the approval of the Chairman, Department of National Security Affairs.

2. Degree Requirements.

Area Specialization and Strategic Planning Options

a. At least 44 units of approved graduate study pertinent to the field of National Security Affairs, of which at least 16 units must be at the 4000 level.

b. The completion of an approved sequence of courses in one of two areas of concentration;

(1) *Area Specialization:* Completion of graduate courses in the geographic areas of specialization, including a 4000 level course.

(2) *Strategic Planning:* Completion of graduate courses in either a geographic or functional area of specialization, including a 4000 level course.

c. Successful completion of departmental comprehensive examination, or completion of an acceptable thesis.

d. Certification of a language proficiency in the area of specialization (Area Specialization Option only).

Naval Intelligence Option

a. A minimum of 44 quarter hours of graduate work, of which at least 12 quarter hours must be at the 4000 level. At least 20 hours must be in the area of national security affairs.

b. Completion of graduate courses in at least three different academic disciplines, including a 4000 level course in at least two of these disciplines.

c. Completion of an acceptable thesis in addition to the 44 quarter hours of course work.

NATIONAL SECURITY AFFAIRS

NS 0010 SEMINAR IN NAVAL INTELLIGENCE (0-2). A continuing series of colloquium seminars in subjects bearing on Naval Intelligence. Seminars will be phased with the development of the curriculum.

NS 0011 SEMINAR IN NATIONAL SECURITY AFFAIRS (0-2). A continuing series of colloquium seminars in subjects bearing on National Security Affairs will be phased with the development of the curriculum.

NS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

NS 0811 PREPARATION FOR COMPREHENSIVE EXAMINATION (0-0). Every student preparing for comprehensive examination will enroll in this course.

Lower Division Course

NS 1368 AMERICAN LIFE AND INSTITUTIONS (3-0). American political institutions and the political, social, economic, and cultural aspects of American life. OPEN ONLY TO ALLIED OFFICERS. Graded on Pass/Fail basis only.

Upper Division Course

NS 2070 NAVAL WARFARE AND NATIONAL SECURITY (4-0). This is an introductory course specifically designed for students in NPS warfare curricula. It focuses on the role of the U.S. Navy as an instrument of U.S. security policy and on the Soviet Navy as the primary naval threat to U.S. interests. It places the use of both navies in the context of a dynamic naval balance and of a changing international system.

Upper Division or Graduate Courses

NS 3032 REVOLUTION AND POLITICAL TERRORISM IN THE MODERN WORLD (4-0). The course covers the selected insurgencies and incidents in detail emphasizing the general historical forces operating, e.g., Nationalist, Socialism, Imperialism, etc., as well as the particular forms of development. Emphasis is on accurate description of events in order to derive patterns of insurgency warfare.

NS 3061 AMERICAN NATIONAL SECURITY POLICY (4-0). An institutional and functional analysis of the national and international factors which shape U.S. defense policy. Attention in the

course is focused on two major areas: 1) the decision-making process, including the legislative-executive budgetary process, as well as the influence of bureaucratic politics and interest group participation upon defense decisions; 2) the problems of strategic choice, including threat analysis, net assessment, deterrence theory, and limited war.

NS 3062 INTELLIGENCE DATA ANALYSIS AND RESEARCH METHODS (4-2). A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of data. Topics include sampling methods, content analysis, data handling and processing, scaling techniques, and parametric and non-parametric tests, with emphasis on application to intelligence. PREREQUISITES: PS 3000 or equivalent, CS 2100. May also be offered as OS 3062.

NS 3078 THE POLITICS OF NATIONAL AND GLOBAL ECONOMIC RELATIONS (4-0). An integrated analysis of the economic and political factors that together determine national and international economic arrangements. The student first addresses the general principles of public finance as a prerequisite for the analysis of budgets, and policy priorities in specific countries and areas. The second portion of the course is concerned with the basic differences, between socialist, capitalist and market economic systems. The remainder of the course is concerned with the changing world economic order, to include issues such as trade, aid, multi-national corporations, technology and strategic resources.

NS 3164 COMPARATIVE IDEOLOGIES (4-0). Analysis of the major ideological forces in contemporary world affairs and their effect upon foreign and defense policies. Special emphasis on Marxian political and social thought. Analysis and comparison on the concepts of democracy, socialism, and fascism. Use of primary source material. PREREQUISITE: A course (upper division or graduate) in the History of Western Philosophy or Political Theory, or consent of instructor.

NS 3169 COMPARATIVE POLITICAL ANALYSIS AND RESEARCH METHODS (4-0). An analytical and comparative study of the form and functioning of the major types of contemporary government with emphasis on the policymaking process and research methods.

NS 3172 PUBLIC POLICY PROCESSES (4-0). A presentation of the processes by which resources are allocated to the production of goods in the Defense sector. Defense budget preparation, Presidential policy-making and management, and Congressional budget action are considered and placed within the context of the theory of public goods. PREREQUISITES: MN 3140, MN 3161, MN 3105. May be given as MN 3172, or with consent of the Instructor.

NS 3262 THEORY AND PRACTICE OF INTERNATIONAL POLITICS (4-0). A theoretical systematic analysis of international relations and a study of the factors, organizational strategies, and techniques of international politics.

NS 3268 PROBLEMS OF GOVERNMENT AND SECURITY IN CONTEMPORARY EUROPE (4-0). Problems of the European political system since World War II. Emphasis on the interrelation of European states (EEC and CMEA), the polarization of Europe between two security systems (NATO and the Warsaw Pact) and relations between the European states and the Third World.

NS 3272 AMERICAN TRADITIONS AND THE NATIONAL INTEREST (4-0). A study of the ideals and values which constitute the essential qualities of American life. The main purpose of this course is to define the American national interest in the international context and the effect of national security policy on the realization of national goals.

NS 3275 INTERNATIONAL LAW (4-0). An introduction to the principles of International Law including sovereignty, territory, recognition, the Law of the Sea, and the laws of war. Special emphasis is on the Law of the Sea, its development, practice, and prospects.

NS 3276 THE LAW OF WAR (4-0). The course presents and analyzes the law of war as it is to be observed and enforced by the Armed Forces of the United States. Special attention is paid to the 1949 Geneva Conventions, the Navy's *Law of Naval Warfare* and the Army's *Law of Land Warfare.*

NS 3280 NUCLEAR WEAPONS AND FOREIGN POLICY (4-0). An interdisciplinary course which covers both the technology and political influences of nuclear weapon systems. The course will emphasize the interaction of nuclear weapon systems

with the foreign policies of the major powers and the political blocs from 1945-present. May also be offered as PH 2280.

NS 3300 PROBLEMS OF GOVERNMENT AND SECURITY IN THE MIDDLE EAST (4-0). An introductory course in Middle Eastern society and politics designed to provide the maximum amount of broad background area knowledge to be utilized in follow-on courses in Middle Eastern politics.

NS 3310 NORTH AFRICA: GOVERNMENT AND SECURITY IN THE MAGHRIB (4-0). This course is designed to extend the student's knowledge of selected North African and Red Sea littoral countries, and to provide some insight into the security problems presented by their domestic politics. In addition, some coverage of central African countries will be included.

NS 3312 SEMINAR ON MIDDLE EAST OIL (4-0). An examination of the oil resources of the Middle East for their impact upon the internal, regional, and international policies of region-states. The role of international oil companies, consuming states, and organizations of exporting countries is studied. Differences in oil resources and revenues are examined and related to different developmental and international policies. The past and future use of oil as a political weapon is discussed and evaluated. The use of revenues from oil is examined for its impact on levels of development and the regional military balance.

NS 3313 PROBLEMS OF GOVERNMENT AND SECURITY IN SUB-SAHARAN AFRICA (4-0). Emergence of independent African states from a shared colonial heritage and their common problems in developing viable modern nation-states. Patterns of international cooperation and conflict among African states, including discussions of African socialism, negritude, pan-Africanism, neutralism, and the continuing problem of South Africa's future. Rival policies of outside powers, including the U.S., the Soviet Union, China and the former colonial powers.

NS 3314 PROBLEMS OF GOVERNMENT AND SECURITY IN ISRAEL (4-0). Israeli cultural, social, and political patterns: Hebraic traditions, Zionism and the creation of Israel, institutional and sociological frameworks for Israeli politics, elite recruitment, perceptions and strategic orientations, security issues in Israeli domestic and foreign policy. PREREQUISITES: NS 3300 or NS 3331, or their equivalent.

NS 3315 THE MIDDLE EAST: THE MILITARY DIMENSION (4-0). An examination of the political, sociological, cultural and strategic roles of the miliary in Middle Eastern history and politics. Among the topics considered are: traditional military patterns, military recruitment, organization, doctrine, and learning experiences.

NS 3316 PROBLEMS OF GOVERNMENT AND SECURITY IN THE NORTHERN TIER: TURKEY, IRAN, AFGHANISTAN, PAKISTAN (4-0). An examination of internal and external political, economic, and social forces in the major non-Arab Middle Eastern states as reflected in their internal development and international policies. Cooperation and conflict in the behavior of these nations toward each other will be explored in the context of their recent efforts at regional cooperation and regional organization (the Sa'dabad Pact, Cento, and RCD). Examination of their relationships to the major outside powers interested in the area, i.e., the U.S. and the Soviet Union. Their relationships both as individual states and as a sub-region with the Arab states of the Middle East. PREREQUISITES: NS 3300 and NS 3320.

NS 3320 INTERNATIONAL RELATIONS AND SECURITY PROBLEMS IN THE MIDDLE EAST (4-0). The course focuses on selected problems affecting American security interests in the Middle East: Strategic waterways, including the Suez Canal, the Turkish Straits, and the Indian Ocean; the politics and problems of access to the area's oil resources; the development of U.S. and Soviet policies toward the area. The foregoing problems will be set in the context of regional international politics.

NS 3330 MILITARY GEOGRAPHY AND HISTORY OF THE MIDDLE EAST (4-0). An intensive course in Middle Eastern history from the viewpoint of geographical and military factors which have shaped the course of events in the area. The geographic (including oceanographic) environment within which military campaigns have been conducted, and which continues to present military problems, is examined. Indigenous and foreign techniques and tactics for dealing with this environment, as well as the historical development

of Middle Eastern military organization are studied.

NS 3331 20TH CENTURY MIDDLE EASTERN MILITARY AND POLITICAL HISTORY (4-0). A follow-on course to NS 3300 which continues the study of Middle Eastern history from the 19th through the 20th Century. Emphasis is placed on the political and military factors which shaped the strategic events. Special attention is given to the genesis and development of nationalist movements in the area and their impact on Middle Eastern politics. PREREQUISITE: NS 3300.

NS 3350 AREA COLLOQUIUM IN MIDDLE EASTERN STUDIES I (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3351 AREA COLLOQUIUM IN MIDDLE EASTERN STUDIES II (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3400 DOMESTIC DETERMINANTS OF SOVIET NATIONAL SECURITY POLICY (4-0). A study of Russian and Soviet political inheritance, ideology, religion, political and economic structures, strategic posture, military capabilities, and leadership.

NS 3410 SOVIET NATIONAL SECURITY AND FOREIGN POLICY-MAKING PROCESSES (4-0). A study of the processes which determine the national security and foreign policy of the Soviet Union. The main focus will be on foreign policy and the dynamics of decision-making in Soviet national security affairs.

NS 3420 SOVIET NAVAL AND MARITIME STRATEGY (4-0). Examination of the roles played by the Soviet Navy, Merchant Marine. Fishing Fleet, and Oceanological Establishment in securing the objectives of the Soviet Government. Topics include: geographic factors affecting Soviet ocean strategies; non-naval strategy trends; international and domestic factors affecting post-1953 naval strategy; development of Soviet naval warfare capabilities; doctrinal and functional analysis of post-1953 trends in naval strategy; command structure; personnel training; law of the sea positions; U.S.-Soviet naval interaction.

NS 3430 SOVIET MILITARY STRATEGY (4-0). Economic, historical and geographic influences on Russian military operations and strategies emphasizing the Soviet era and alternative future Soviet military developments and strategies are examined.

NS 3440 COMPARATIVE COMMUNIST POLITICAL SYSTEMS (4-0). An analysis of structure and policy-making processes of existing communist political systems, of major functions performed by them, and significant factors affecting system development.

NS 3450 AREA COLLOQUIUM IN SOVIET STUDIES I (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3451 AREA COLLOQUIUM IN SOVIET STUDIES II (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3500 PROBLEMS OF GOVERNMENT AND SECURITY IN THE CARIBBEAN AREA (4-0). A study of the political, economic, social, and cultural characteristics and the security problems of the countries in the Caribbean area. Included are Mexico, Central America, the Caribbean Island countries, the Guianas, Venezuela, and Colombia.

NS 3510 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH AMERICA (4-0). A study of the political, economic, social, and cultural characteristics and the security problems of the countries in South America, excluding the Guianas.

NS 3520 PROBLEMS OF DIPLOMACY AND SECURITY IN LATIN AMERICA AND THE CARIBBEAN (4-0). A study of the political, economic, and military relationships among the Latin American nations, and the role of Latin America in world politics. Special emphasis is placed on U.S. relations with Latin America.

NS 3605 GEOGRAPHY, HISTORY AND CULTURES OF ASIA (4-0). An introduction to Asia, including Japan, China, India, Southeast Asia, West and Central Asia. The course addresses the people and their cultures, civilizations, social organization, economic and political development through four distinct periods: before the coming of Europe, the colonial period, the era of national development and modernization, and the period since World War II.

NS 3606 PROBLEMS OF GOVERNMENT AND SECURITY IN PENINSULAR SOUTHEAST ASIA (4-0). Problems of modernization, war, and revolution in the governments and economies of the states of Peninsular Southeast Asia: cultural determinants; problems of ethnic minorities; role of religions; nationalism, communism, and wars of liberation; the overseas Chinese problem; the absorption of South Vietnam into the Democratic Republic of Vietnam; the transformation of Cambodia and Laos into Communist States; the Thai and Burmese military regimes and their problems of modernization and security; the strategic interests of the major powers.

NS 3608 PROBLEMS OF GOVERNMENT AND SECURITY IN INSULAR SOUTHEAST ASIA (4-0). Problems of modernization, war and revolution in the government and economies of the states of Insular Southeast Asia: cultural determinants; problems of ethnic minorities; roles of religions; nationalism, communism, and wars of liberation; the overseas Chinese problem; communal and leadership problems in Malaysia, Republic of Singapore, Philippines, and Indonesia. Problems of security; the strategic interests of the major powers.

NS 3610 PROBLEMS OF GOVERNMENT AND SECURITY IN EAST ASIA AND THE PACIFIC OCEAN (5-0). Problems of industrialization, revolution, and conflict in the East Asian States: China's relations with contiguous states; Sino-Soviet state, party, and ideological differences; Chinese military and naval command structure; Japan's new dynamic position; U.S. and Japanese security issues; problems of the two Koreas; Soviet and American Far Eastern interests and policies; analysis of present and future military capabilities and strategies of East Asian States.

NS 3611 PROBLEMS OF GOVERNMENT AND SECURITY IN CONTEMPORARY JAPAN (4-0). A study of contemporary Japan since the end of World War II: Occupation policies of the U.S.; the new Constitution; revival and nature of Japanese party government; parties and their platforms; styles of leadership; Japanese economic policies; access to resources; the energy problem; urbanization and breakdown of old value systems. Japan's security problems; Korea; the approach of separating politics and economics; the two-China problem; relations with the Soviet Union; the nuclear problem; relations with Europe; the security relationship of the U.S. and Japanese armed forces.

NS 3612 PROBLEMS OF GOVERNMENT AND SECURITY IN THE PEOPLE'S REPUBLIC OF CHINA (4-0). A study and analysis of Communist China since the end of World War II: The structure of government and party; the CCP, history, facts, legends and leaders; the politics of a communist system. Population; land reform and the organization of the agricultural sector; industrialization and expansion of China's resource base; the People's Liberation Army, its command structure, political role, ground forces, navy, air force, and nuclear weapons systems; China's foreign and international security policies; relations with the Soviet Union, Japan, Southeast Asia, South Asia, and Third World Countries; the nature and significance of relations with the United States.

NS 3620 PROBLEMS OF GOVERNMENT AND SECURITY IN SOUTH ASIA AND THE INDIAN OCEAN (4-0). Problems of nationalism, modernization, and security in the governments and economies of India. Pakistan, Bangladesh, Afghanistan, and Sri Lanka. Indian-Pakistani relations; relations with China; the Tibetan and Kashmir problems; strategic interests of the major powers; Soviet interests and naval expansion in the Indian Ocean.

NS 3650 AREA COLLOQUIUM IN ASIAN STUDIES I (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign

policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3651 AREA COLLOQUIUM IN ASIAN STUDIES II (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3700 STRATEGIC GEOGRAPHY AND THE HISTORY OF EUROPE (4-0). The course links the political and military experiences of the European states and political blocs of the 19th and 20th Centuries with the decisive constraints and opportunities of geography. The advanced elements of geography, which serve as the fundamental framework in political and military decision-making, are systemically arranged and examined within Europe. Strategic position, area, physiography, population, technology and economic resources are presented as the basic elements which have influenced the political and military events of the recent past and can be used to help in forecasting the future.

NS 3701 RECENT HISTORY OF EUROPE AND THE U.S.S.R. (4-0). This course continues the narrative and analysis began in NS 3700 Strategic Geography and History of Europe, bringing the student from the Bolshevik Revolution and the Treaty at Versailles to the present day.

NS 3710 INTERNATIONAL RELATIONS AND SECURITY PROBLEMS OF SOUTHERN EUROPE AND THE MEDITERRANEAN (4-0). This course is designed to provide an introduction to security problems in and around the Mediterranean. It will focus on the strategic problems of access to, and defense of the Mediterranean littoral: communication routes in and through the Mediterranean; Western and Soviet interests in the Mediterranean; politics and policies of the surrounding states.

NS 3750 AREA COLLOQUIUM IN EUROPEAN STUDIES I (2-0). A combined NSP/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3751 AREA COLLOQUIUM IN EUROPEAN STUDIES II (2-0). A combined NPS/DLI colloquium covering designated topics. Open to students completing the language portion of their studies. Cultures; current domestic and foreign policy; and security problems of selected countries in the areas of specialization. Graded on Pass/Fail basis only.

NS 3800 PROBLEMS OF GOVERNMENT AND SECURITY OF THE SCANDINAVIAN-BALTIC REGION (4-0). This course analyzes the political, economic, social, and security problems faced by the Scandinavian-Baltic countries. The role they play on the northern flank of NATO will be examined as well as their position vis-a-vis the growing threat of Soviet military and naval power in the Baltic and Norwegian seas.

NS 3900 INTERNATIONAL ORGANIZATION (4-0). Analysis of the international system, its evolution from separatism and alliances to multinational organization and beyond. American goals, objectives, and resources are examined in bilateral relationships, regional groupings, functional approaches, and general organization. Collective security and peacekeeping efforts, pacific settlement, arms control and disarmament, and institution building.

NS 3901 OCEAN POLICY (4-0). Examination of policy choices for the United States and other governments concerning political, military, legal, environmental, and economic problems of the sea.

NS 3902 SCIENCE, TECHNOLOGY, AND PUBLIC POLICY (4-0). An inquiry into the role of science and technology in the formulation and conduct of national policy. Interactions between scientific communities, government, and militarq services.

Graduate Courses

NS 4000 PERSPECTIVES ON AMERICAN CIVILIZATION (4-0). This course, especially designed for the foreign area studies (attach9e) program, is an interdisciplinary study of American culture, involving the political, economic, social, philosophical and literary development of the Nation from 1789 to the present.

NS 4061 SURVEY OF STRATEGIC STUDIES (4-0). An extensive survey of the classical and contemporary literature on strategic thinking; national objectives and strategic alternatives; deterrence, counterforce, arms control, counter insurgency, compellence; components and rules of the international strategic system; arms competitions, nuclear proliferation, terrorism. Student projects on current strategic problems are a major component of the course. PREREQUISITES: NS 3061, NS 3262.

NS 4063 NAVAL THREAT ANALYSIS (4-0). Introduction to different types of naval threat analyses and to the purposes, problems and procedures associated therewith. Attention is paid to sources of information available to analysts and to threat analysis products put out by the U.S. Intelligence activities. Students will engage in a classroom simulation of an operational intelligence activity charged with analyzing a "developing threat". SI access required.

NS 4077 STRATEGIC RESOURCES AND U.S. NATIONAL SECURITY POLICY (4-0). Analysis of the problems of access to global resources and their utilization: agricultural production; access to critical raw materials; problems and politics of oil; national and international implications of various strategies of self-sufficiency and interdependency. Emphasis is placed on the security problems arising from the geographic distribution of international resources. PREREQUISITES: NS 3061, NS 3262.

NS 4140 PROBLEMS OF SECURITY ASSISTANCE AND ARMS TRANSFERS (4-0). An analysis of the patterns, purposes and effects of cross-national security assistance, including arms sales and the transfer of technology. Special topics include: factors dominating the arms transfer policies of the major powers; the role of the military in recipient nations; the role of the military attaché; the design, execution and evaluation of security assistance programs. PREREQUISITES: NS 3061 or NS 3262.

NS 4161 AMERICAN NATIONAL SECURITY OBJECTIVES AND NET ASSESSMENT (4-0). Comparative analysis of trends in U.S. and Soviet security policy, military forces, manpower, and capabilities. Special attention is paid to familiarizing students with original source material and major elements in current controversial national security issues. Topics covered include nuclear capabilities and doctrine, BMD and air defenses, civil defense, combined arms employment NATO Warsaw Pact military balance, naval forces, and trends in the U.S. and Soviet economies especially as they affect the allocation of resources to defense.

NS 4207 SPECIAL TOPICS IN THE ANALYSIS OF INTELLIGENCE PROBLEMS (4-0). An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: NS 3062, OS 3207, NS 4063. May also be offered as OS 4207.

NS 4273 AMERICAN FOREIGN POLICY AND WORLD POLITICS (4-0). An advanced study of the underlying assumptions and objectives of American security and foreign policy. Policy formulation, world politics, alliance and treaty systems; effects on security problems of budgets, weapons systems, research and development, international economic issues, the functioning of regional security systems in crises; problems of threat and intelligence determination. Use of primary source material. This course is designed to develop a capacity for problem analysis or to encourage opportunities for research specialization. PREREQUISITES: NS 3400, NS 3610.

NS 4279 DIRECTED STUDIES IN NATIONAL SECURITY AFFAIRS (Credit Open). Directed studies in military technical systems.

NS 4300 SEMINAR IN SECURITY PROBLEMS OF THE MIDDLE EAST (4-0). Advanced Middle Eastern politics and the security problems they present to U.S. decision-makers. The central theme of the course is U.S. interests in the Middle East, how these interests are threatened, and what policy alternatives have been proposed to secure them. PREREQUISITE: NS 3300 or NS 3320.

NS 4330 SEMINAR IN MIDDLE EASTERN CIVILIZATIONS (4-0). Description and analysis of the four major cultural traditions of the Middle East: Arabic, Persian, Judaic, and Turkish. Students read translations of selected classical and contemporary writings from each of these traditions, and secondary materials concerning social

and cultural institutions. PREREQUISITES: NS 3300 or NS 3330 or consent of the Instructor.

NS 4400 SEMINAR IN SOVIET SECURITY PROBLEMS (4-0). Course is designed to provide students with an opportunity to engage in advanced study and research in specialized topics relating to the USSR. PREREQUISITES: Two 3000 level courses on the Soviet Area.

NS 4425 ADVANCED TOPICS IN SOVIET NAVAL AFFAIRS (4-0). Advanced study and research in Soviet naval and maritime affairs. Topics include: decision-making processes, scenarios, warfare capabilities and support systems, missions; and U.S.-Soviet naval interactions.

NS 4630 INTERNATIONAL SECURITY PROBLEMS OF ASIA AND THE ADJACENT OCEANS (4-0). An advanced study of the international security interests and problems of the Asian states: changing military capabilities and the balance of forces; problems of military and naval threats; economic resources for war; alliances, bases, and security systems; forecasting of international conflict on the continent; assessment of the Asian policies of the U.S. PREREQUISITES: 8 units of Asian studies or consent of the Instructor.

NS 4700 SEMINAR IN SOVIET-EUROPEAN RELATIONS (4-0). A seminar intended to deepen the student's knowledge of current issues in Soviet and European affairs through weekly presentations and discussions by visiting scholars and government officials and by the preparation and presentation of the students' own research papers.

NS 4701 SEMINAR IN POLITICAL AND SECURITY PROBLEMS OF EUROPE (4-0). A research seminar on political and security issues in contemporary Europe. Students conduct and present original research on selected issue, or related issues, in specific European countries of subregions. The issue around which the seminar is structured varies from term to term. It is chosen to meet the research interests of each group of students enrolled in the course.

NS 4710 SEMINAR IN SINO-SOVIET RELATIONS (4-0). Advanced analysis of Sino-Soviet relations. Emphasis is placed on political, economic and military factors which have shaped historical confrontations and contemporary conflicts, and which will influence the policies of both nations in the future. The special features of the course include consideration of the influence of Sino-Soviet conflicts upon global military and diplomatic problems. Open to Asian and Soviet Studies students and to other students with consent of the Instructor.

DEPARTMENT OF OCEANOGRAPHY

DALE FREDERICK LEIPPER, Professor of Oceanography; Chairman (1968)*; B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography (La Jolla), 1950; Hon. D.Sc., Wittenberg Univ., 1968.

ROBERT SANBORN ANDREWS, Associate Professor of Oceanography (1968); B. of Geol. Engr., Univ. of Minnesota, 1958; M.S., Univ. of Washington, 1965; Ph.D., Texas A&M Univ., 1970.

ROBERT HATHAWAY BOURKE, Associate Professor of Oceanography (1971); B.S., Naval Academy, 1960; M.S., Oregon State Univ., 1969; Ph.D., 1972.

ALDEN BUFFINGTON CHACE, Jr., Lieutenant Commander, U.S. Navy; Assistant Professor of Oceanography (1976); B.S., Naval Academy, 1962; M.S., Naval Postgraduate School, 1969; Ph.D., Univ. of Rhode Island, 1976.

WARREN WILSON DENNER, Associate Professor of Oceanography (1964); B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963; Ph.D., 1969.

ROLAND WILLIAM GARWOOD, JR., Assistant Professor of Oceanography (1976); B.S. Bucknell Univ., 1967; Ph.D., Univ. of Washington, 1976.

EUGENE CLINTON HADERLIE, Distinguished Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.D., 1950.

GLENN HAROLD JUNG, Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas A&M Univ., 1955.

ROBERT GEORGE PAQUETTE, Professor of Oceanography (1971); B.S., Univ. of Washington, 1936, Ph.D., 1941.

WARREN CHARLES THOMPSON, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

EDWARD BENNETT THORNTON, Associate Professor of Oceanography (1969); B.A., Williamette Univ., 1962; B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1965; M.E.C.E., Univ. of Florida, 1966; Ph.D., 1970.

EUGENE DEWEES TRAGANZA, Associate Professor of Oceanography (1970); B.A., Indiana Univ., 1955; M.S., Texas A&M Univ., 1959; Ph.D., Univ. of Miami, 1966.

STEVENS PARRINGTON TUCKER, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1972.

JOSEPH JOHN VON SCHWIND, Associate Professor of Oceanography (1967); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah at Salt Lake City, 1960; Ph.D., Texas A&M Univ., 1968.

JACOB BERTRAM WICKHAM, Associate Professor of Oceanography (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

Oceanography is the study of the sea from the points of view of the basic sciences: physics, biology, chemistry, and geology. It emphasizes relationships with engineering and meteorology. The Department of Oceanography is the center for such studies at the Naval Postgraduate School. Its functions are to prepare officers to make best use of the ocean environment in the course of their duties, to

prepare them to carry out and evaluate research in oceanography, and to carry out oceanographic research of both basic and/or applied nature.

The curriculum and research vessels are sponsored by the Oceanographer of the Navy. Research is supported by grants from various government agencies including the Office of Naval Research.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN OCEANOGRAPHY

MASTER OF SCIENCE IN OCEANOGRAPHY

Entrance to a program leading to the degree of Master of Science in Oceanography requires a baccalaureate degree in a field appropriate to the oceanography option cposen. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry.

The degree of Master of Science in Oceanography requires:

a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 Oceanography series. The entire sequence of courses for the particular option selected must be approved by the Department of Oceanography.
b. An acceptable thesis on a topic approved by the Department of Oceanography.

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

1. **Direct** entrance to a program leading to the degree Master of Science in Meteorology and Oceanography requires a baccalaureate degree in meteorology and/or oceanography or equivalent. This normally permits the validation of required undergraduate courses such as physics, chemistry, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event the program may be lengthened by one or two quarters.

Indirect entry into the program is possible for persons lacking a baccalaureate degree in meteorology or oceanography through the oceanography curriculum (440). Minimal entrance requirements here include differential and integral calculus, and a year each of college physics and chemistry.

2. The degree of Master of Science in Meteorology and Oceanography requires:

a. Completion of 48 quarter hours of graduate courses in meteorology and oceanography including MR/OC 4413, MR 4322, MR 4323 and 10 quarter hours in the 4000 oceanography series. The degree program must be approved by both the Department of Meteorology and the Department of Oceanography.

b. Completion of an acceptable thesis on a topic approved by either department.

DOCTOR OF PHILOSOPHY

Department of Oceanography admission requirements for the degree of Doctor of Philosophy are:

a. a Master's degree (or the equivalent) in science or engineering or

b. a Bachelor's degree with a high QPR or

c. a successful first graduate year on a Master's program, with clear evidence of research ability.

A student who desires to undertake doctoral work in oceanography should discuss his program first with the Chairman, Department of Oceanography. He should then follow regular guidelines as outlined by the Curricular Officer and the Academic Associate.

LABORATORY FACILITIES

The department has two beachfront laboratories, a small biological oceanography laboratory with salt water aquaria and filtered salt water circulating system and a 4,000 square-foot laboratory with lecture room and student study areas. Equipment includes a wave tank, drying oven, and high pressure test chamber. Additionally, a small ocean engineering laboratory, chemical oceanography laboratory, and geological oceanography laboratory are maintained.

The School operates the R/V ACANIA, a 126-foot vessel, for use in oceanographic instruction and research.

Oceanographic equipment installed in the beach area includes wave and tide gauges for recording nearshore wave action and local tide fluctuations.

OCEANOGRAPHY

OC 0110 APPLICATIONS SEMINAR (1-0). Presentation of D.o.D. related research activities, applications to weapons and warfare systems, utilization of oceanography and meteorology in specific billets, presentations by faculty, staff, selected students and visiting authorities. PREREQUISITE: Enrollment in an Environmental Sciences curriculum.

OC 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OC 2110 INTRODUCTION TO OCEANOGRAPHY (3-0). An introductory course treating physical and chemical properties of sea water, submarine geology, and marine biology; the heat budget of the oceans; water masses and general circulation; currents, waves, and tides. PREREQUISITE: None.

OC 2120 SURVEY OF OCEANOGRAPHY (4-0). Beginning physical oceanography, average values of ocean parameters, an integrated view of the whole field of oceanography including biological, geological, and chemical. PREREQUISITE: Calculus and college physics, or permission of Instructor.

OC 2430 ENVIRONMENTAL POLLUTION (3-0). A survey of air and water pollution theory and associated problems with specific case studies. Pertinent basic principles from oceanography and meteorology will be presented. PREREQUISITE: None. May also be offered as MR 2430.

Upper Division or Graduate Courses

OC 3150 GEOPHYSICAL RANDOM PROCESSES (4-2). Statistical evaluation of measurements in random media: ocean, atmosphere, earth; basic probability, probability distributions, probability density functions; random variables, random functions; harmonic analysis of random functions. Time series analysis: covariance, convolution, energy density spectrum, cross spectrum. PREREQUISITES: MA 2121, MA 3132, OC 3221, OC 4211 concurrently.

OC 3151 GEOPHYSICAL RANDOM PROCESSES (3-1). A shorter version of OC 3150 for students who have had prior courses in statistics and probability. PREREQUISITE: MR 2520.

OC 3212 POLAR METEOROLOGY/OCEANOGRAPHY (3-1). Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice; its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Geology and geophysics. PREREQUISITES: MR 3230, OC 3221.

OC 3220-3221 PHYSICAL OCEANOGRAPHY I-II (3-0). Beginning physical oceanography; the ocean basins, age and origin of oceans, physical properties of sea water, thermal properties of water and ice, distribution of variables, physical characteristics of estuaries. Ocean current systems, water masses, geostrophic flow, dynamic height computation, upwelling, heat budget, heat distribution and thermal structure, waves, internal waves and tides, selected regional studies in physical oceanography. For oceanography and air-ocean science majors.

OC 3240 OPERATIONAL ENVIRONMENTAL PRODUCTS (0-4). Meteorological and oceanographical products available to the operating fleet from Fleet Numerical Weather Central/Fleet Weather Centrals and other sources and described and applied to the diagnosis and prognosis of tactical environmental parameters for both current and historical situations. PREREQUISITES: MR 2210 and OC 3221.

OC 3261 OCEANOGRAPHIC FACTORS IN UNDERWATER SOUND (4-0). This course examines the environmental factors which influence sound propagation in the ocean and the effects these factors have in acoustic forecasting. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, biological effects, reflection characteristics of ocean surface and bottom, signal fluctuations, and forecasting ocean thermal and sound speed structure. The students will review and report on

related papers from the current literature. This course is designed for the Engineering Acoustics Curriculum. PREREQUISITES: PH 3452, OC 2120.

OC 3265 ENVIRONMENTAL FACTORS IN UNDERWATER ACOUSTICS (4-0). This course examines the environmental factors which influence sound propagation in the ocean. Factors considered include temporal and spatial variations in sound velocity profiles, ambient noise, radiated noise, absorption, reflection characteristics of the sea surface and ocean bottom, signal fluctuations, and transmission loss models. This course is designed for the ASW curriculum. PREREQUISITES: OC 2120, MR 3413, PH 3471.

OC 3320 GEOLOGICAL OCEANOGRAPHY (3-3). Geological processes, materials, and methods in marine geology; physiography of the sea floor; sedimentology; marine geophysics surveys; properties and distribution of recent marine sediments, especially as relevant to underwater acoustics; structure and origin of ocean basins; field trips to local sites and aboard oceanographic research vessel. PREREQUISITE: OC 2110 or OC 2120 or OC 3220.

OC 3321 MARINE GEOPHYSICS (3-0). Theory and methods for marine geophysics surveys, with emphasis on gravity, magnetism, seismic and acoustic wave propagation, heat flow, and radioactivity; geophysical anomalies associated with major seafloor features; acoustic reflectivity of the sea floor; marine geodesy. PREREQUISITE: OC 3320 or OC 3323.

OC 3322 PRINCIPLES OF GEOLOGY (2-0). Survey of physical geology directed toward processes, materials, and methods in marine geology; geologic time, minerals and rocks, structural geology, weathering, gradation, and earth physics. PREREQUISITE: OC 2110 or OC 2120 or OC 3220 or college introductory oceanography.

OC 3323 GEOLOGICAL OCEANOGRAPHY (2-0). Physiography of the sea floor; sedimentology; marine geophysics surveys; properties and distribution of recent marine sediments, especially as relevant to underwater acoustics; structure and origin of ocean basins. PREREQUISITE: OC 3322 or college geology and introductory oceanography.

OC 3420 BIOLOGICAL OCEANOGRAPHY (3-3). General biological principles; the sea as an environment for life; major plant and animal groups in the sea; plankton and food cycles; primary productivity; boring and fouling organisms; bioacoustics, bioluminescence, and deep scattering layers; dangerous marine organisms. Laboratory work and field trips dealing with marine organisms. PREREQUISITE: None.

OC 3520 CHEMICAL OCEANOGRAPHY (3-3). Basic chemistry of solutions; chemical compositions of the oceans (dissolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient, and other cycles in the sea; desalination; corrosion, geochemistry. PREREQUISITES: OC 3221, CH 1001 or CH 2001 or equivalent.

OC 3610 OCEAN WAVE FORECASTING (2-2). Prediction and observation of wind-generated ocean waves in deep water, interpretation of wave characteristics in spectral and statistical terms for operational briefings, and wave-related influences on operations. PREREQUISITES: OC 4211, OC 3150.

OC 3617 ACOUSTICAL FORECASTING (2-2). Development of synoptic prediction techniques applied to the upper ocean and other environmental factors affecting underwater sound propagation. Current acoustical models, oceanographic input to the models and the tactical and strategic utilization of the output are described. Laboratory exercises illustrate principles developed during lectures. PREREQUISITE: OC 4260 and SECRET clearance.

OC 3621 REGIONAL MILITARY OCEANOGRAPHY (1-4). Application of the full breadth of the oceanography program, including physical phenomena, geology, biology, chemistry, acoustics and air/sea interaction in order to objectively analyze the significance of the total environment on the various aspects of naval warfare for specific oceanic areas of operation. PREREQUISITES: OC 3221, 3320, 3420, 3520.

OC 3625 ENVIRONMENTAL PREDICTION FOR UNDERWATER SOUND PROPAGATION (2-1). Development of synoptic prediction techniques applied to environmental factors affecting

underwater sound propagation. These factors include space and time variation of ocean density structure and associated parameters, behavior of vertical and horizontal temperature gradients, air-sea interaction, advection and mixing effects on ocean density structure. Current acoustic forecasting models will be studied in light of adequacq of environmental input data, realism, and computational approximations. This course is designed for the ASW program. PREREQUISITES: OC 2120, PH 2472, MR 3413.

OC 3709 SCIENTIFIC CRUISE EXPERIENCE (0-4). Laboratory course taught to introduce the student to oceanographic operations at sea. The use of standard oceanographic instruments is stressed in the conduct of a comprehensive oceanographic survey; processing of data and storage of data and samples are studied and accomplished. Interpretation of results is introduced. PREREQUISITES: OC 3820 and OC 2110 or OC 2120 or OC 3221.

OC 3801 OCEAN OPERATIONS I (3-1). This course includes a comprehensive coverage of the present state-of-the-art associated with types of floating platforms; stationary platforms; submersible design, operation, and applications; manipulator design; diving operations; underwater construction and structure; energy sources; pressure vessels and testing programs; unmanned vehicles and platforms; deep drilling; dynamic positioning; buoys and deep water buoyancy; in general those operations associated with search, rescue, recovery, and salvage. Field trips made to laboratories deeply involved in oceanographic engineering work. PREREQUISITES: None.

OC 3820 PRINCIPLES OF MEASUREMENT (3-2). The application of the basic principles of mechanics, heat, electricity, sound and optics to oceanographic instrumentation employed by the Navy. Upper air and satellite developments; design and operation of oceanographic instruments; recording of oceanographic observations. PREREQUISITE: MA 2121.

OC 3901 BASIC HYDROGRAPHY (3-2). An introduction to the techniques used in hydrographic survey operations and nautical chart construction. Topics include vertical data planes, geodetic surveying, position, fixing methods, echo sounders and depth corrections, and chart construction. Laboratory exercises illustrate principles developed during lectures. PREREQUISITES: OC 2110 or OC 2120, OC 3320.

Graduate Courses

OC 4211 WAVES AND TIDES (4-0). Linear theory of surface and internal waves; theory of finite amplitude waves; windwave spectra; theory of the astronomical tides; tide analysis and prediction; seiches and co-oscillations. PREREQUISITE: OC 4321 or MR 4321 or ME 2201.

OC 4213 COASTAL OCEANOGRAPHY (3-2). Shoal-water wave processes, breakers and surf; nearshore water circulations; beach characteristics; littoral drift; coastal hydraulics, storm tides. PREREQUISITE: OC 4211.

OC 4260 SOUND IN THE SEA (4-0). Oceanographic effects on sound propagation, especially on absorption, reflection, refraction; scattering, ambient noise; operational aspects for Navy use. Synoptic prediction techniques applied to the upper ocean involving a practical approach to the solution of heat budget, techniques for forecasting the thermal structure and regional variance of oceanic acoustic properties. PREREQUISITES: PH 3431 or 3432 and SECRET clearance.

OC 4321 INTRODUCTORY GEOPHYSICAL FLUID DYNAMICS (4-0). Development of the hydrodynamical equations, vector and tensor operations, forces acting on fluids (surface forces, body forces); stream function, velocity potential, geostrophic, gradient and inertial flows; baroclinic and barotropic fluids, vertical variation of horizontal velocity; Ekman spiral applied to ocean and atmosphere; geopotential surfaces, level of no motion; vorticity and divergence equations. PREREQUISITES: MA 2048 and MA 2121.

OC 4322 OCEAN DYNAMICS (4-0). The wind-driven ocean circulation, real fluid boundary conditions, steady-state linear theories, steady-state non-linear theories, vorticity arguments; topographical influence on ocean currents, significance of inertial and frictional terms in an ocean with bottom topography; time dependent motion, Rossby waves. PREREQUISITE: OC 4321.

OC 4413 AIR-SEA INTERACTION (4-0). Consequences of momentum, heat and moisture exchange between atmosphere and ocean; recent semiempirical formulae relating air-sea fluxes to

large-scale meteorological parameters; concepts in turbulence and similarity theory for stationary turbulent regimes adjacent to the air-sea interface; turbulence sensors, bulk aerodynamic formulae for estimating air-sea boundary fluxes; mutual atmosphere and ocean response times and synoptic scale energy exchanges; investigations of the role of the atmosphere and oceans of global energy balance and climate formation. PREREQUISITES: OC 3150, OC 4322 or MR 4322, MR 2210, or consent of Instructor.

OC 4421 MARINE ECOLOGY (1-4). The habits, classification, development and adaptations of marine animals and plants with particular reference to ecology of Monterey Bay. The relationships of physical, chemical, geological, and biological factors of the environment to marine organisms. Primarily laboratory investigations and field work dealing with the intertidal areas, harbors, estuaries, and the near-shore pelagic and benthic environments of the associated organism. PREREQUISITE: OC 3420.

OC 4422 MARINE BIODETERIORATION (1-1). A study of the organisms involved in the biodeterioration of engineering materials. Subjects included are marine fouling, wood and rock borers, and the effects of biological organisms on the corrosion of metals. PREREQUISITE: OC 3420.

OC 4612 POLAR OCEANOGRAPHY (3-2). Oceanographic and geophysical structure of the polar regions; sea-ice properties, formation, growth, deformation and disintegration; sea-ice drift due to wind and currents. The course is frequently conducted as a two-week course with field experience at the Naval Arctic Research Laboratory, Barrow, Alaska. Laboratory studies of the physical, chemical, petrographic structure and strength properties of ice are conducted. PREREQUISITE: OC 3221.

OC 4800 SPECIAL TOPICS IN OCEANOGRAPHY (1-0 to 4-0). Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the Department Chairman and Instructor.

OC 4802 OCEAN OPERATIONS II (3-1). Considerations of more complex aspects of oceanographic engineering operations, including such subjects as deep mooring techniques; platform and ship motions; large object towing forces; heavy lifts and line dynamics; wave loads on platforms and floating breakwaters; hydrodynamic aspects of falling objects; considerations of high pressure structural design; participation in a laboratory exercise involving conducting an oceanographic engineering operation at sea. PREREQUISITE: OC 3801.

OC 4803 PHYSICAL PROPERTIES OF MARINE SEDIMENTS (2-3). This course involves the elementary study of the physical behavior of marine sediments including such subjects as types of sediments, coring and testing equipment, general physical characteristics of sediments, methods of detailed physical and chemical analysis, in-situ testing, pressure effects, scour and fill, turbidity flows. Application is made to penetration and breakout of objects and to trafficability. PREREQUISITE: OC 3320.

OC 4860 PHYSICS OF THE EARTH (3-0). Physical properties and composition of the earth's interior; review of the theories of the earth's formation; study of the crustal structure through gravity, magnetic, seismic, and other geophysical evidence. PREREQUISITE: OC 3320 or consent of the Instructor.

OC 4900 SEMINAR IN OCEANOGRAPHY (2-0). Students in the various oceanography curricula report results of their own research in presentations for group discussion. PREREQUISITE: Preparation of a thesis or a research paper concurrently.

DEPARTMENT OF OPERATIONS RESEARCH

MICHAEL GRAHAM SOVEREIGN, Associate Professor of Operations Research; Chairman (1970)*; B.S., Univ. of Illinois, 1959; M.S., Purdue Univ., 1960; Ph.D., 1965.

ALVIN FRANCIS ANDRUS, Associate Professor of Operations Research and Statistics (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

DONALD ROY BARR, Professor of Operations Research and Statistics (1966); B.A. Whittier College, 1960; M.S. Colorado State Univ., 1962; Ph.D., 1965.

DONALD ROBERT BOUCHOUX, Lieutenant, U.S. Navy; Instructor in Operations Research (1976); B.A., Boston College, 1968; M.A., Naval Postgraduate School, 1976.

GORDON HOOVER BRADLEY, Associate Professor of Operations Research (1973); B.S., Lehigh Univ., 1962; M.S., 1964; Ph.D., Northwestern Univ., 1967.

GERALD GERARD BROWN, Associate Professor of Computer Science and Operations Research (1976); B.A., California State Univ. at Fullerton, 1968; M.B.A., 1969; Ph.D., Univ. of California at Los Angeles, 1974.

RICHARD WESLEY BUTTERWORTH, Associate Professor of Operations Research (1969); B.S., Univ. of California at Berkeley, 1966; M.S., 1967; Ph.D., 1969.

ROBERT JONES CASTLEMAN, JR., Lieutenant Colonel, U.S. Army; Instructor in Operations Research (1976); B.S., U.S. Military Academy, 1960; M.S., Naval Postgraduate School, 1970.

JOSEPH HENRY CYR, JR., Lieutenant Commander, U.S. Navy; Assistant Professor of Operations Research (1973); B.S., Purdue Univ., 1960; M.S. Naval Postgraduate School, 1969.

JAMES DANIEL ESARY, Professor of Operations Research and Statistics (1970); A.B., Whitman College, 1948; M.A., Univ. of California at Berkeley, 1951; Ph.D., 1957.

ROBERT NEAGLE FORREST, Associate Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

DONALD PAUL GAVER, JR., Professor of Operations Research and Statistics (1971); S.B., Massachusetts Institute of Technology, 1950; S.M., 1951; Ph.D., Princeton Univ., 1956.

JAMES KERN HARTMAN, Associate Professor of Operations Research and Administrative Sciences (1970); B.S., Massachusetts Institute of Technology, 1965; M.S., Univ. of Nebraska, 1967; Ph.D., Case Western Reserve Univ., 1970.

GILBERT THOREAU HOWARD, Associate Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

ROBERT LEROY HUBBARD, Visiting Professor of Operations Research (1976); B.S., Univ. of North Carolina, 1954; Ph.D., 1961.

HAROLD JOSEPH LARSON, Professor of Operations Research and Statistics (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

PETER ADRIAN WALTER LEWIS, Professor of Operations Research and Statistics (1971); B.A., Columbia College, 1954; B.S., Columbia Engineering School, 1955; M.S., 1957; Ph.D., Univ. of London, 1964.

GLENN FRANK LINDSAY, Associate Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., Ohio State Univ., 1962; Ph.D., 1966.

KNEALE THOMAS MARSHALL, Professor of Operations Research (1968); B.Sc., Univ. of London, 1958; M.S.,

Univ. of California at Berkeley, 1964; Ph.D., 1966.

ALAN WAYNE McMASTERS, Associate Professor of Operations Research and Administrative Sciences (1965); B.S., Univ. of California at Berkeley, 1957; M.S., 1962; Ph.D., 1966.

PAUL ROBERT MILCH, Associate Professor of Operations Research and Statistics (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

DOUGLAS ELMER NEIL, Assistant Professor of Operations Research (1972); B.A., Univ. of Southern California, 1965; M.S., Univ. of Pacific, 1967; Ph.D., North Carolina State Univ., 1971.

SAMUEL HOWARD PARRY, Associate Professor of Operations Research (1973); B.S., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964; Ph.D., Ohio State Univ., 1971.

GARY KENT POOCK, Professor of Operations Research and Man-Machine Systems (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

WILLIAM MICHAEL RAIKE, Associate Professor of Operations Research (1971); B.A., Northwestern Univ., 1964; M.S., 1965; Ph.D., 1967.

ROBERT RICHARD READ, Professor of Operations Research, Probability and Statistics (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California at Berkeley, 1957.

FRANCIS RUSSELL RICHARDS, Associate Professor of Operations Research (1970); B.S. Louisiana Polytechnic Institute, 1965; M.S., Celmson Univ., 1967; Ph.D., 1971.

BRUNO OTTO SHUBERT, Associate Professor of Operations Research, Probability and Statistics (1970); M.S., Czech. Technical Univ. at Prague, 1960; Ph.D. Charles Univ. at Prague, 1964; Ph.D., Stanford Univ., 1968.

REX HAWKINS SHUDDE, Associate Professor of Operations Research (1962); B.S., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California at Berkeley, 1956.

JAMES GROVER TAYLOR, Associate Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

MARLIN ULUESS THOMAS, Associate Professor of Operations Research (1971); B.S., Univ. of Michigan, 1967; M.S.E., 1968; Ph.D., 1971.

JOSEPH BRYCE TYSVER, Associate Professor of Operations Research and Statistics (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

LEIS EDWARD WALDEISEN, Commander, U.S. Navy; Assistant Professor of Operations Research (1974); B.S., Univ. of San Francisco, 1960; M.A., Univ. of New Mexico, 1965; Ph.D., Texas Tech Univ., 1974.

ALAN ROBERT WASHBURN, Associate Professor of Operations Research (1970); B.S., Carnegie Institute of Technology, 1962; M.S., 1963; Ph.D., 1965.

PETER WILLIAM ZEHNA, Professor of Operations Research and Statistics (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956; Ph.D. Stanford Univ., 1959.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES

Programs leading to degrees must be arranged in consultation with the Chairman, Department of Operations Research.

MASTER OF SCIENCE IN APPLIED SCIENCE

Students with acceptable academic backgrounds may enter a program leading to the degree of Mas-

ter of Science in Applied Science. The program of each student seeking this degree must contain a minimum of 20 quarter hours in operations research at the graduate level, including work at the 4000 level. Additionally, the program must contain a minimum of 12 graduate quarter hours in an approved sequence of courses outside the Department of Operations Research. A total minimum of 12 quarter hours at the 4000 level plus an acceptable thesis is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate level courses, including at most 8 quarter hours for a thesis.

   a. At least 18 quarter hours of 4000 level operations research/systems analysis courses.
   b. An elective sequence approved by the Department of Operations Research.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Research. This credit shall not count toward the requirement stated in 2a.

DOCTOR OF PHILOSOPHY

1. Students currently enrolled in the Master of Science program and who wish to be considered for doctoral work in Operations Research should announce their intentions as early as possible, preferably by the fifth quarter. The department chairman will examine the applicant's qualifications, modify his second year program, and monitor his progress. The schoolwide requirements are contained in the General Information section of this catalogue.

2. Students wishing to enter directly into the doctoral program should write to the department chairman. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases the student must fulfill the schoolwide requirements contained in the General Information section of this catalogue.

3. If the applicant is selected, he must pursue a course of in-depth study in mathematical programming, stochastic processes and a third area approved by his doctoral committee. He must be advanced to candidacy and write an acceptable thesis pertinent to an areas of specialization selected from the following four: stochastic processes, mathematical programming, decision sciences and human factors.

OPERATIONS ANALYSIS

OA 0001 SEMINAR FOR OPERATIONS RESEARCH/SYSTEMS ANALYSIS STUDENTS (0-2). Guest lecturers. Review of experience tours. Thesis and research presentations. PREREQUISITE: None.

OA 0810 THESIS RESEARCH FOR OPERATIONS RESEARCH/SYSTEMS ANALYSIS STUDENTS (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2600 INTRODUCTION TO OPERATIONS RESEARCH (2-0). A first course in Operations Research for students in the OA curriculum. Early origins of Operations Research and development through World War II to current practice. Introduction to fundamental concepts of the OR approach including the role of analytic models, decision variables, and measures of effectiveness. Model verification and interpretation of study results are discussed. PREREQUISITE: None.

OA 2910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background in operations research.

Upper Division or Graduate Courses

OA 3200 COMPUTATIONAL METHODS FOR OPERATIONS RESEARCH (3-2). Application programming for OR, Markov models, random

sample generation, statistical data reduction; introduction to interactive modeling, CP/CMS, comparing interactive and batch methodologies, interactive data analysis. PREREQUISITE: CS 2600.

OA 3604 LINEAR PROGRAMMING (4-0). Theory of optimization of linear functions subject to linear constraints. The simple algorithm, duality, dual simplex algorithm, sensitivity analyses, parametric linear programming, transportation algorithm and matrix payoff games. Applications to resource allocation, manpower planning, transportation and communications network models, ship scheduling, and elementary strategic games. Introduction to machine computing and MPS. PREREQUISITE: MA 2042.

OA 3605 METHODS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). A first course designed to survey the methodology of operations research and systems analysis. Topics in this sequence include: dynamic programming, PERT and PERT/COST, queueing, reliability, maintenance, replacement, networks, stochastic models, and allocation of search. PREREQUISITE: OA 3604.

OA 3620 INVENTORY I (4-0). A Study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite and finite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic "order up to R" model. Single period stochastic models. PREREQUISITES: MA 2110, PS 3302.

OA 3653 SYSTEM SIMULATION (4-0). Computer simulation as a problem solving technique. Subject areas covered include: discrete event digital simulation methodology, Monte Carlo techniques, simulation programming in FORTRAN and other available simulation languages, variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 2600 or equivalent. PS 3303 or equivalent.

OA 3654 WAR GAMING (3-2). Consideration of the problems inherent in the construction and use of manual and computer war games. Problems in the analysis of results of such games. PREREQUISITES: OA 3653, PS 3302. Graded on Pass/Fail basis only.

OA 3656 OPERATIONS RESEARCH PROBLEMS IN SPECIAL WARFARE (4-0). The applicability of operations research to unconventional warfare and counterinsurgency. Normative and descriptive models. Consideration of special problems with emphasis on problem formulation. PREREQUISITES: OA 3604, PS 3303.

OA 3657-3658 HUMAN FACTORS IN SYSTEMS DESIGN I-II (4-0 and 3-0). The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. Man-machine interface and man's motor and sensory capacities. PREREQUISITES: PS 3303, OA 3604.

OA 3660 ANALYSIS OF OPERATIONAL DATA (3-1). Analysis of real world operational data. The processing and interpretation of incomplete operational data. Problems will be chosen from current military problems. PREREQUISITES: PS 3303, OA 3653 (concurrently).

OA 3704 STOCHASTIC MODELS I (4-0). The primary goal of the course is to gain the theory necessary for stochastic modeling with Markov models. Particular topics include the homogenous and inhomogenous Poisson process, filter Poisson process, compound Poisson process, stationary Markov chains. The theory is augmented by examination and discussion of actual applications such as manpower management. PREREQUISITE: Basic probability with calculus as in PS 3302.

OA 3900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

OA 3910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

Graduate Courses

OA 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (4-0). Attribute and variables sampling plans. MIL.STD. sampling plans with

modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: PS 3303.

OA 4323 DECISION THEORY (3-0). Basic concepts, Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluations trials. PREREQUISITE: PS 3303.

OA 4401 MANPOWER AND PERSONNEL MODELS (4-0). The objective of this course is to enable the student to make use of the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Applications in the form of current military models are included. PREREQUISITE: OS 3212 or OA 3604 and OA 3704.

OA 4403 INDUSTRIAL ENGINEERING REQUIREMENTS DETERMINATION (4-0). The objective is to enable the student to use some of the tools of industrial engineering in the determination of the quantity and quality of manpower required in military systems. Techniques include motion and time study, work sampling, predetermined time standards, work design and layout, materials handling, procedures review and process design. Applications for ship and squadron manning documents and SHORESTAMPS are included. PREREQUISITE: OS 3212 or OA 3604 and OA 3704.

OA 4614 COST ESTIMATION (4-0). Advanced study in the methods and practice of systems analysis with emphasis on cost analysis; cost models and methods for total program structures and single projects; relationship of effectiveness models and measures to cost analyses; public capital budgeting of interrelated projects; detailed examples from current federal practices. PREREQUISITE: MN 3611.

OA 4615 ECONOMETRICS (4-0). An introduction to the construction of testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITES: PS 3303, MN 3610.

OA 4616 DEFENSE EXPENDITURE AND POLICY ANALYSIS (4-0). A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them. PREREQUISITE: MN 3611.

OA 4617 CAMPAIGN ANALYSIS (4-0). Study of the development, use, and state of the art of Campaign Analysis. Emphasis is placed on the different views of problem formulation and alternative approaches to campaign modeling so that the graduate will be able to improve campaign analyses. The structure of campaign analysis and the current spectrum of interaction assessment models used in campaign analysis are investigated. The students will study and discuss significant portions of actual campaign analyses such as SEAMIX, Navy Fighter Study, etc. The classification requirement for the course is SECRET - NOFORN. PREREQUISITE: OA 3654.

OA 4621 INVENTORY II (4-0). A study of stochastic inventory models. Single period models with time dependent costs, constrained multiple item single period models, deterministic and stochastic dynamic inventory models, the (r,R) periodic review model, the Q = 1 continuous review model, demand forecasting. PREREQUISITES: OA 3704, OA 3620.

OA 4622 SEMINAR IN SUPPLY SYSTEMS (4-0). A survey of supply systems, not only from an inventory point of view, but also as a critical area in logistics. Topics for discussion will be selected from the current literature and will be chosen according to student's interests. Periodically, experts in the supply field will provide guest lectures on current research areas. PREREQUISITES: OA 4621, OA 3704, or departmental approval.

OA 4631 NONLINEAR AND DYNAMIC PROGRAMMING (4-0). Introduction to modern optimization techniques and multistate decision processes. Kuhn-Tucker necessary and sufficient conditions for optimality, quadratic and separable programming, basic gradient search algorithms. SUMT penalty function method, dynamic programming. Applications to weapons assignment, force structuring, parameter estimation for nonlinear or constrained regression, personnel as-

signment and resource allocation. PREREQUISITE: OA 3604.

OA 4632 MATHEMATICAL PROGRAMMING (4-0). Advanced topics in linear programming. Large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, probabilistic programming, formulation and solution procedures for problems in integer variables. Applications to the cutting stock problem, capital budgeting, large scale distribution systems, weapon systems allocations and others. PREREQUISITE: OA 3604.

OA 4633 NETWORKS FLOWS AND GRAPHS (4-0). Survey of solution techniques for problems which can be related to problems involving flows in networks. Elements of graph theory, max-flow mincut theorem, shortest route problems, minimal cost flows, out-of-kilter algorithm, CPM, PERT/Cost, and PERT/Time. PREREQUISITE: OA 3604.

OA 4634 GAMES OF STRATEGY (4-0). Games as mathematical models of conflict situations. Fundamental concepts; objective and subjective basis. The canonical, dynamic, and characteristic function forms, Zero-sum, n-person noncooperative and multistage games. Coalitions and cooperative games with and without side payments. Postulates of rational behavior, dominance, and stability. Valuation and bargaining models. PREREQUISITE: MA 3610.

OA 4635 NONLINEAR PROGRAMMING (4-0). Continuation of OA 4631. Advanced topics in nonlinear programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods and examination of recent literature in nonlinear programming. PREREQUISITE: OA 4631.

OA 4636 DYNAMIC PROGRAMMING (4-0). A continuation of OA 4631. Basic theory of dynamic programming with numerous optimization and resource allocation applications in the areas of reliability design, target selection, inventory theory, project selection, and others. PREREQUISITE: OA 4631.

OA 4638 OPTIMIZATION OF TIME-SEQUENTIAL PROCESSES (4-0). Study of time-sequential decision processes. Modelling and optimization of dynamic systems with one or more decision makers. Applications of modern optimal control theory and differential games to problems of military operations research. Typical areas of application are time-sequential combat games (air-war allocation strategies, fire-support allocation strategies), inventory systems, searching for targets, strategic missile allocations, pursuit and evasion, engagement of targets of opportunity. PREREQUISITE: OA 4631 or consent of the Instructor.

OA 4642 ADVANCED TOPICS IN WAR GAMING AND SIMULATION (3-2). A greater-depth coverage of material introduced in OA 3653 and OA 3654. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and instructor. This course is particularly appropriate for those doing theses in this area. PREREQUISITE: OA 3654 and Departmental approval.

OA 4651 SEARCH THEORY AND DETECTION (4-0). Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITE: PS 3303 or equivalent.

OA 4652 OPERATIONS RESEARCH PROBLEMS IN NAVAL WARFARE (3-0). Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communications, and ECM problems. PREREQUISITE: OA 4651.

OA 4653 OPERATIONAL TEST AND EVALUATION (3-2). This course relates the theory and techniques of operations research to the problems associated with operational test and evaluation. Specific examples of exercise design, reconstruction, and analysis are examined. PREREQUISITES: OA 3660, OA 4651 or OA 4654.

OA 4654 COMBAT MODELS (4-0). Introduction to the scientific study of warfare. Methodologies

for the analysis and evaluation of military operations with emphasis on system effectiveness and measures of effectiveness. Study of models of combat processes (in particular, target acquisition and destruction). Introduction to Lanchester-type models of warfare and theory of duels. PREREQUISITE: OA 3704 or equivalent.

OA 4655 QUANTITATIVE ANALYSIS OF TACTICS (4-0). Applications of models of combat processes to the quantitative study of military tactics. Review of combat modelling theories. Class project of applying some quantitative methodology to a tactical problem of current interest. Advanced topics in Lanchester theory of combat: variable attrition-rate coefficients, heterogeneous forces, breakpoints, secondary effects of casualties, suppersive effects. Mathematical models of tactical allocation. PREREQUISITE: OA 4654 or consent of the Instructor.

OA 4656 OPERATIONS RESEARCH OF ARMY WEAPONS SYSTEMS (4-0). The study of qualitative and quantitative methods applicalbe to the Army weapons system evaluation process. Topics covered are: The Life Cycle Systems Management Model, Army Organization for Operations Research, Operations Research in the Budgeting Process, the Cost and Operational Effectiveness Analysis and the Cost and Training Effectiveness Analysis. The course includes a critical examination of combat models commonly used in systems effectiveness estimation. Existing analyses are reviewed through the case study method. PREREQUISITE: Departmental approval.

OA 4662 RELIABILITY AND WEAPONS SYSTEM EFFECTIVENESS MEASUREMENT (4-0). Component and system reliability functions, and other descriptors for the reliability aspect of system effectiveness. Relationships between system and component reliability. Point and interval estimates of reliability parameters under various life testing plans. Illustrations of current methods of reliability assessment from appropriate MILSTD's and manuals. PREREQUISITE: OA 4705 (may be taken concurrently) or equivalent.

OA 4680 HUMAN PERFORMANCE EVALUATION (4-0). Experimental considerations, strategy, and techniques in evaluation of human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variables affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3657.

OA 4685 SKILLED OPERATOR PERFORMANCE (3-2). First part of the course is devoted to an examination of the theoretical foundations of skilled performance. The second half of the course is devoted to the study of the acquisition, development and prediction of skilled operator performance in the operational setting. PREREQUISITE: OA 3657.

OA 4690 EVALUATION OF HUMAN FACTORS DATA (3-2). The course is primarily concerned with collection, evaluation, and analyses of data obtained from human subjects. Problem solving and extraction of results from actual human factors data is emphasized. Orientation of the course is toward applied solutions rather than theoretical education. PREREQUISITES: OA 3657, PS 3302, or equivalent.

OA 4695 OPERATIONS RESEARCH IN MAN-MACHINE SYSTEMS (4-0). The course emphasizes the application of operations research techniques to man-machine system design and evaluation problems. Specific methodologies will be incorporated from mathematical programming, stochastic processes, decision theory, and other related areas. Quantitative methods for performance will be treated using such concepts as reliability, information theory, and signal detection theory. A portion of the course will be devoted to summarizing approaches to real world problems incorporating current methods from the literature. PREREQUISITES: OA 3657, OA 3604, OA 3704, and OA 4705 (may be taken concurrently).

OA 4705-4706 STOCHASTIC MODELS II-III (3-2) and (4-0). Experience in stochastic modeling is gained by performance of a suitable project entailing data collection and analysis, formulation of model assumptions and application of the model to answer specific questions or help explain a particular phenomenon; study of non-Markovian systems. Queueing theory topics relevant to applications including deterministic queues, priority queueing systems with application such as cm computer time sharing, inequalities and approximations for general single served queues, multichannel and tandom queue approximations, and heavy traffic

queues with applications of the diffusion process. PREREQUISITE: OA 3704.

OA 4910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research and Departmental approval.

OA 4930 READINGS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Departmental approval. Graded on Pass/Fail basis only.

OTHER SERVICE COURSES

Upper Division Courses

OS 2201 ELEMENTS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). An introductory course. Topics covered include nature, origin, and contemporary status of operations analysis; problem formulation. PREREQUISITE: PS 2501 or equivalent.

Upper Division or Graduate Courses

OS 3062 INTELLIGENCE DATA ANALYSIS (4-2). A survey of methods and techniques for synthesis, analysis, interpretation, and reporting of intelligence data. Topics include sampling methods, content analysis, data handling and processing overview, scaling techniques, and parametric and nonparametric tests with emphasis on application. The student will be exposed to a wide spectrum of data relating to international problems, with particular emphasis on international commerce and trade, and national maritime capabilities. PREREQUISITES: PS 3000 or equivalent, CS 2100. May also be offered as NS 3062.

OS 3201-3202 FUNDAMENTALS OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS I-II (4-0). Selected operations research techniques, primarily the elements of probability and statistics, applicable to the prediction of system cost, schedule, and effectiveness. Special topics in statistics, appropriate to applications in costing, quality assurance, and life testing. PREREQUISITE: Differential and integral calculus.

OS 3203 SURVEY OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). A survey of the military applications of operations analysis/systems analysis techniques of particular interest to the student. The applications usually covered are selected from decision, waiting lines, resource allocation, replacement, cost-effectiveness, inventory theory, and search models. The techniques needed for these applications are developed as required and usually include topics in linear programming (including the simplex method), probability theory, nonlinear programming statistics (including Bayesian and classical), dynamic programming and simulation. PREREQUISITE: PS 3411 or equivalent.

OS 3205 OPERATIONS RESEARCH FOR COMPUTER SCIENTISTS (4-0). An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, PS 3414 and CS 0110.

OS 3206 OPERATIONS RESEARCH FOR MECHANICAL ENGINEERS (4-0). A survey of operations research techniques of particular interest to the mechanical engineer. Linear programming, sequencing and scheduling, integer programming, decision theory, geometric programming, networks, simulation. Probability concepts developed as needed. PREREQUISITES: MA 1100 and MA 2045 or equivalent.

OS 3207 OPERATIONAL ANALYSIS FOR NAVAL INTELLIGENCE (4-0). An introduction to the methodology and techniques of operations research, with special emphasis on specific areas relevant to naval intelligence such as decision-making under risk and uncertainty, forecasting, search, detection, resource allocation, and queues. PREREQUISITE: PS 3000 or equivalent.

OS 3208 OPERATIONS ANALYSIS FOR ELECTRONIC WARFARE (4-0). This course deals with applications of quantitative models to operational electronic warfare problems, with the underlying idea being to make decisions by optimizing some measure of effectiveness (MOE). Topics covered include ESM, ECM/ECCM, strike warfare, ASMD, and cost/effectiveness tradeoffs.

PREREQUISITES: Calculus, PS 3411 and OS 3653.

OS 3210 OPERATIONS RESEARCH FOR COMPUTER SYSTEMS MANAGERS (4-0). A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Model formulation, decision theory, linear programming, project management techniques, inventory models, queueing and simulation, reliability and maintainability. Examples will illustrate the application of these techniques to the management of computer systems. PREREQUISITES: MA 2300, PS 3011.

OS 3211 OPERATIONS RESEARCH FOR COMMUNICATIONS MANAGERS (4-0). A one-quarter survey of operations research techniques of particular interest to students in communications management. Model formulation, decision theory, games, linear programming, network flows, CPM and PERT, reliability and maintainability, queueing theory, and systems simulation. PREREQUISITES: MA 2300, PS 3000.

OS 3212 OPERATIONS RESEARCH FOR MANAGEMENT (4-0). A survey of problem solving techniques for operations research. Topics include decision theory, linear programming, analysis of two-person games, Lanchester models of combat, project scheduling, inventory models, queueing models, and simulation. PREREQUISITES: MA 2300 and PS 3005.

OS 3214 OPERATIONS RESEARCH METHODOLOGY (4-0). Survey of Operations Research techniques not covered in OS 3212. Topics may include simulation, search theory, extensions of combat models, network flows, and Markov chains. PREREQUISITES: PS 3211 and OS 3212 concurrently.

OS 3215 SELECTED TOPICS IN MANAGEMENT SCIENCE (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. May be repeated for credit if the content changes. PREREQUISITE: Departmental approval.

OS 3306 SYSTEMS EFFECTIVENESS CONCEPTS AND METHODS (4-0). An introduction to system reliability, maintainability, and effectiveness analysis. Failure (repair) rates and mean times to failure (repair). Models for aging and completion. Block diagrams and fault trees. Life testing. Availability, interval reliability, and the synthesis of reliability, maintainability, and effectiveness considerations. PREREQUISITES: OS 3202, OS 3203 (concurrently).

OS 3322 INTRODUCTION TO QUALITY ASSURANCE (4-0). Characterization of quality requirements for materiel inspection procedures. Acceptance sampling, MilStd plans. Product and process quality cost analysis. Statistical control of quality. For students in Management. PREREQUISITE: PS 3211 or OS 3202 or equivalent.

OS 3390 COMPUTATION AND COMPUTER SIMULATION (4-2). Programming in FORTRAN and specialized simulation languages, with applications to the solution of ASW problems by simulation. Designed for students in ASW curriculum.

OS 3651 SEARCH, DETECTION, AND LOCALIZATION MODELS (4-0). An introduction to the decision problems associated with Navy detection systems. The relation of detection models to search and localization models, measures of effectiveness of search/detection systems, and the optimum allocation of search effort are discussed. The last week of the course requires participation in an ASW related group project. This course is designed for the ASW curriculum. PREREQUISITE: PS 3411 and SECRET clearance.

OS 3652 INTRODUCTION TO COMBAT MODELS AND WEAPONS EFFECTIVENESS (4-1). This course deals with the application of more or less abstract models to military problems. Topics include Lanchester's Theory, Game Theory, Reliability Theory, Systems Effectiveness, and War Gaming. The last week of the course requires participation in an ASW related group project. This course is designed for the ASW curriculum. PREREQUISITES: PS 3411 and MA 2129 and SECRET clearance.

OS 3653 SYSTEM SIMULATION (4-0). Computer simulation as a problem solving technique. Subject areas covered include: Discrete event digital simulation methodology, Monte Carlo techniques, simulation programming in FORTRAN and other available simulation languages, variance reduction techniques, design of simulation experiments and analysis of results. PREREQUISITES: CS 0110 or equivalent, PS 3411 or equivalent.

OS 3655 SIMULATION AND WAR GAMING

(2-2). Design, implementation and use of digital simulation models will be covered with special emphasis on features common to EW problems. War gaming will be discussed and game using the digital computer will be played and critiqued by the class. Basic topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation, special purpose simulation and gaming languages, and estimating the development and computational cost of complex software systems. PREREQUISITES: CS 2700, OS 3411, OS 3661 or equivalent.

OS 3659 HUMAN FACTORS ENGINEERING (3-0). An introduction to human factors engineering for students in other fields such as engineering. Designed to give the student an appreciation of man's capacities and limitations and how these can affect the optimum design of the man-machine system. Emphasis on integration of human factors into the system development cycle considering such topics as manpower/personnel costs, control and display design, human energy expenditure, physiological costs, and evaluation systems. PREREQUISITE: A previous course in probability and statistics.

OS 3661 DECISION ANALYSIS AND DATA ANALYSIS (4-0). This course relates the theory and techniques of data analysis and operations research to ASW analysis problems. It is primarily for students in the ASW program. Emphasis is placed upon the analysis of data in the ASW environment. PREREQUISITES: PS 3411 or equivalent.

OS 3665 HUMAN VIGILANCE PERFORMANCE (3-1). Course involves an examination of man's attentiveness and capability in the detection of changes in stimulus events over prolonged periods of observation. Topics to be covered include theories of vigilance; task, signal, subject and environmental influences on performance; physiological and psychological responses and vigilance performance measurement. This course is designed for the ASW curriculum. PREREQUISITE: OS 3661.

OS 3702 WEAPONS SYSTEMS MODELING AND OPTIMIZATION (4-1). This is the second Systems course for students in the Weapon Systems Technology (WST) option of Curriculum 530. It emphasizes quantitative methods for formulating and solving trade-off decisions. Topics include linear and non-linear optimization, methods of cost estimation including present value computations, decisions under uncertainty, game theory, modeling measures of effectiveness, and applications. PREREQUISITES: PS 3414, OS 3661, MN 2701.

Graduate Courses

OS 4063 FORECASTING THREAT ANALYSIS AND NET ASSESSMENT (4-0). A study of the intuitive, exploratory and normative forecasting methods, including brainstorming, Delphi, time series, scenario writing, uncertainty, cost benefit, input-output approaches. Conflict modelling; introduction of models of armament races and international conflict. Implications of such models for analyzing threats; search procedures for generating alternatives. Net assessment of such alternatives. PREREQUISITES: OS 3207, GV/OS 3062, GV 3420. May also be offered as GV 4063.

OS 4207 SPECIAL TOPICS IN THE ANALYSIS OF INTELLIGENCE PROBLEMS (4-0). An examination of special intelligence problems and cases with emphasis on problem and project formulation, structure, and management as well as the interpretation and communication of study results. Applications of cost/benefit and input-output modelling to intelligence decision problems such as collection management, collection system design, data handling and manipulation. The last portion of the course will focus on student presentation of thesis research. PREREQUISITES: GV/OS 3062, OS 3207, GV/OS 4063. May also be offered as NS 4207.

OS 4643 ASW WAR GAMING (3-0). The development and use of war games for the analysis of ASW problems. The form and qualities of the various kinds of war games are discussed and a manual-machine ASW Campaign model is developed and used. PREREQUISITE: OS 3661 or equivalent and SECRET clearance.

OS 4653 OPERATIONAL TEST AND EVALUATION (4-0). This course is designed for systems technology students. It deals with the problems associated with the tests and evaluations of military weapons systems, exercises and tactics. Included are concepts of the design of experiments; analysis of operational data; reliability; measures of effec-

tiveness; and exercise design, reconstruction and analysis. Examples and case studies which involve ASW, EW, and AAW are examined. PREREQUISITE: OS 3661.

OS 4703 RELIABILITY, MAINTAINABILITY, AND SAFETY ANALYSIS OF WEAPONS SYSTEMS (4-0). Modeling and measurement of factors contributing to system effectiveness. Reliability. Maintainability. Safety. Life and repair distributions for components, block diagrams, and fault trees. Estimation for components and systems. Optimal redundancy and repair. PREREQUISITES: PS 3414, OS 3661, MN 2701.

PROBABILITY AND STATISTICS

Upper Division Courses

PS 2350 DATA ANALYSIS (2-0). A survey of practical techniques for the analysis of experimental data. Basic probability and mathematical expectation. Binomial, Poisson, Gaussian and other distributions. Variance and covariance, error propagation and curve fitting. Must be taken concurrently with PH 2600. PREREQUISITE: Calculus.

PS 2501 INTRODUCTION TO PROBABILITY AND STATISTICS (4-0). Selected topics from basic probability and statistics, using some elementary calculus concepts. Topics include probability axioms, discrete and continuous random variables typical distributions, independence and independent sampling, and point and interval estimation. PREREQUISITES: MA 1115, MA 1120 or equivalent.

Upper Division or Graduate Courses

PS 3000 PROBABILITY AND STATISTICS FOR COMMUNICATIONS MANAGEMENT (4-0 or 5-0). An introductory course in probability and statistics designed for applications to Communications Management problems. The topics covered will include frequency distributions and descriptive measures, rules for computing probabilities, binomial and normal distributions, central limit theorem, sampling distributions, statistical inference including regression, and analysis of variance. PREREQUISITE: College algebra.

PS 3005 PROBABILITY (3-0). A one-quarter course in probability. Random variables, probability axioms, independence, moments, derived distributions. Bayes Theorem, sampling, sample statistics. This course is designed primarily for students in management. PREREQUISITE: MA 2305 or equivalent.

PS 3011-3012 PROBABILITY AND STATISTICS FOR MANAGEMENT I-II (5-0) and (4-0). A treatment of selected topics in probability and statistics for management applications using elementary concepts from calculus; includes probability models, discrete and continuous random variables, some important distributions, sampling theory and an introduction to statistical inference. Includes inference for normal populations, estimation procedures, nonparametric procedures and linear models. PREREQUISITE: MA 2300 or equivalent.

PS 3211 STATISTICS (4-0). A survey of managerial statistics and decision analysis modeling. Topics include parameter estimation, confidence intervals, hypothesis testing, regression analysis. PREREQUISITES: MA 2300 and PS 3005 or their equivalents.

PS 3301 PROBABILITY (4-0). Probability axioms and event probability. Random variables and their probability distributions. Moment generating functions, moments and other distribution characteristics. Distribution families characterized by parameters. Functions of a random variable. Jointly distributed random variables, independence and conditional distributions; correlation. PREREQUISITE: None.

PS 3302 PROBABILITY AND STATISTICS (4-1). Random samples. Derived distributions of functions of several random variables. Order statistics, the t and F distributions. Limiting distributions, the central limit theorem and approximations. Bivariate normal distribution; extension to the multivariate normal family. Point estimation; unbiasedness, maximum likelihood and Bayes. Interval estimation; confidence intervals and Bayesian intervals. PREREQUISITE: PS 3301.

PS 3303 STATISTICS (4-1). Confidence interval estimation and hypothesis testing. Regression and correlation analysis. Elements of the analysis of variance. Nonparametric inference. Applications to reliability, quality assurance, and operations analysis problems. PREREQUISITE: PS 3302.

PS 3411-3412 APPLIED PROBABILITY THEORY I-II (4-1) and (4-0). Axiomatic probability, random variables, distribution functions, transformation of random variables, limiting distribution, stationary and ergodic processes. Stochastic processes, time series, linear mean-square estimation; Brownian motion and Markov processes and Poisson processes. PREREQUISITES: MA 1121 and PS 2501 or equivalents.

PS 3414 APPLIED PROBABILITY AND STATISTICS (4-0). A first course in applied probability and statistics for students with a background in mathematics and engineering. Discrete and continuous distributions, sampling, estimation, hypothesis testing, regression analysis, applications to reliability and system effectiveness modeling and measurement. PREREQUISITE: Courses in differential and integral calculus.

PS 3419-3420 PROBABILITY AND STATISTICS FOR SYSTEMS TESTING AND EVALUATION I-II (4-1) and (3-0). Basic probability laws, discrete and continuous random variables and their distributions, useful probability distributions, random samples, sample statistics and their distributions, introduction to stochastic processes including Markov Chains, stationarity and ergodicity. Point and interval estimation of parameter, tests of hypotheses, methods of regression analysis, basic statistics of control charts and applications to DoD problems. PREREQUISITE: MA 1100.

PS 3421 NONPARAMETRIC STATISTICS (4-0). One-sample tests, two-sample test, tests for independence, nonparametric analysis of variance and correlation statistics. PREREQUISITE: Consent of Instructor.

Graduate Courses

PS 4001 PROBABILITY THEORY (3-0). Axiomatic probability, random variables and their probability distributions, parameters of probability distributions, characteristic functions and limit theorems. PREREQUISITE: Advanced calculus or consent of Instructor.

PS 4321 DESIGN OF EXPERIMENTS (3-1). Theory of the general linear hypotheses. Analysis of variance. Planning of experiments. Simple factorial experiments. Randomized block and Latin squares. PREREQUISITE: OA 3303.

PS 4431 ADVANCED PROBABILITY (3-0). Convergence almost surely, in probability and in quadratic mean. Distribution function and characteristic functions. Infinitely divisible laws. Strong and weak laws of large numbers. Classical central limit problems moder central limit problems. PREREQUISITE: MA 3606 and Departmental approval.

PS 4432-4433 STOCHASTIC PROCESSES I-II (4-0). The Kolmogorov theorem; analytic properties of sample functions; continuity and differentiability in quadratic mean; stochastic integrals, stationary processes. Stationary and non-stationary problems; Martingale, limit theorems and the invariance principle. PREREQUISITE: PS 4431.

PS 4440 TIME SERIES ANALYSIS (4-0). Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral window. Ergotic properties. Problems of inference in time series analysis. Introduction to the analysis of multivariate processes. Course should be taken concurrently with PS 4432.

PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: Consent of Instructor. Graded on Pass/Fail basis only.

DEPARTMENT OF PHYSICS AND CHEMISTRY

KARLHEINZ EDGAR WOEHLER, Professor of Physics; Chairman (1962)* B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

ROBERT LOUIS ARMSTEAD, Associate Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1964.

FRED RAMON BUSKIRK, Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

ALFRED WILLIAM MADISON COOPER, Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's University of Belfast, 1961.

JOHN NIESSINK COOPER, Professor of Physics (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

ALAN BERCHARD COPPENS, Associate Professor of Physics (1964); B.Eng.Phys., Cornell Univ., 1959; M.S. Brown Univ., 1962; Ph.D., 1965.

EUGENE CASSON CRITTENDEN, JR., Distinguished Professor of Physics (1953); B.A., Cornell Univ., 1934; Ph.D., 1938.

HARVEY ARNOLD DAHL, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

JOHN NORVELL DYER, Professor of Physics (1961); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

HARRY ELIAS HANDLER, Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

DON EDWARD HARRISON, JR., Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

OTTO HEINZ, Professor of Physics (1962); B.A. Univ. of California at Berkeley, 1948; Ph.D., 1954.

RAYMOND LEROY KELLY, Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

HERMAN MEDWIN, Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S. Univ. of California at Los Angeles, 1948; Ph.D., 1953.

EDMUND ALEXANDER MILNE, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S. California Institute of Technology, 1950; Ph.D., 1953.

JOHN ROBERT NEIGHBOURS, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

RAINER PITTHAN, Assistant Professor of Physics (1973); B.S., Univ. of Marburg, 1962; M.S., Darmstadt Institute of Technology, 1967, Ph.D., 1972.

WILLIAM REESE, Professor of Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

RICHARD ALAN REINHARDT, Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

GEORGE WAYNE RODEBACK, Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

CHARLES FREDERICK ROWELL, Associate Professor of Chemistry (1962); B.S. Syracuse Univ., 1956; M.S., Iowa State Univ., 1959; Ph.D., Oregon State Univ., 1964. (on leave of absence)

JAMES VINCENT SANDERS, Associate Professor of Physics (1961);

B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

GORDON EVERETT SCHACHER, Associate Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

JOHN WILFRED SCHULTZ, Associate Professor Chemistry (1958); B.S., Oregon State College, 1953; Ph.D., Brown Univ., 1957. (on leave of absence)

FRED RICHARD SCHWIRZKE, Associate Professor of Physics (1967); B.S., Univ. of Rostock, 1950; M.S., Univ. of Karlsruhe, 1953; Ph.D., 1959.

WILLIAM MARSHALL TOLLES, Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A. Univ. of California at Los Angeles, 1948; Ph.D., 1951.

WILLIAM BARDWELL ZELENY, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S. Syracuse Univ., 1958; Ph.D., 1960.

EMERITUS FACULTY

NEWTON WEBER BUERGER, Professor Emeritus (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1939.

WILLIAM PEYTON CUNNINGHAM, Distinguished Professor Emeritus (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

AUSTIN ROGERS FREY, Distinguished Professor Emeritus (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

WILLIAM WISNER HAWES, Professor Emeritus (1952); B.S., Ch.Eng., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

SYDNEY HOBART KALMBACH, Professor Emeritus (1947); B.S., Marquette Univ., 1934; M.S., 1937.

GILBERT FORD KINNEY, Distinguished Professor Emeritus (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

GEORGE DANIEL MARSHALL, JR., Professor Emeritus (1946); B.S., Yale Univ., 1930; M.S., 1932.

GEORGE HAROLD MCFARLIN, Professor Emeritus (1948); B.A., Indiana Univ., 1925; M.A., 1926.

LEONARD OLIVER OLSEN, Professor Emeritus (1960); B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

MELVIN FERGUSON REYNOLDS, Professor Emeritus (1949); B.S. Franklin and Marshall College, 1932; M.S. New York Univ., 1935; Ph.D., 1937.

JOHN DEWITT RIGGIN, Professor Emeritus (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

DEGREE REQUIREMENTS

The Department of Physics and Chemistry offers the MS and BS degrees in Physics, in Chemistry and in Applied Science. In addition, the Ph.D. is offered by the Department. Upon approval by the Department, courses taken at other institutions may be applied towards satisfying degree requirements.

MASTER OF SCIENCE IN PHYSICS

1. A candidate for the degree Master of Science in Physics must complete satisfactorily a program of study which includes a minimum of 30 quarter hours of physics courses (not including thesis) distributed among courses at the graduate level; of this 30 hours at least 15 hours must be at the 4000 level. Upon approval of the Chairman of the Physics and Chemistry Department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20

hours entirely of 4000 level physics courses. In addition, all students must present an acceptable thesis.

2. The following specific course requirements must be successfully completed for a student to earn the degree of Master of Science in Physics:

a. Thermodynamics and Statistical Mechanics — the student must take a two-quarter sequence or present equivalent preparation in this area.
b. A course in Advanced Mechanics or Quantum Mechanics.
c. A course in Electromagnetism at the 4000 level.
d. An advanced course in Modern Physics.
e. Specialization, to include at least two advanced courses in an area of specialization.

3. Programs leading to the Master of Science degree in Physics must be approved by the Chairman of the Department of Physics and Chemistry.

MASTER OF SCIENCE IN APPLIED SCIENCE

A candidate for the degree Master of Science in Applied Science must complete satisfactorily a program of study which includes 20 quarter hours of courses in physics and/or chemistry at the graduate level including work at the 4000 level; a departmentally approved sequence containing a minimum of 12 hours at the graduate level which is taken outside the Department of Physics and Chemistry; of the above 32 quarter hours of work at the graduate level at least 12 must be in 4000 level courses. The candidate must present an acceptable thesis on a topic given prior approval by the Department of Physics and Chemistry. Final approval of all programs leading to the Master of Science in Applied Science shall be obtained from the Chairman of the Department of Physics and Chemistry.

DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Department in several areas of specialization which currently include Acoustics, Atomic Physics, Solid State Physics, Theoretical Physics, Nuclear Physics and Plasma Physics.

Requirements for the degree may be grouped into 3 categories: courses, thesis research and examinations in major and minor fields and languages.

The required examinations are described elsewhere in this catalogue in the section Requirements for the Doctor's Degree. In addition to the school requirements the department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Advanced Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. (PH 4171, 4371, 4971, 4972, 4973, 4571, 4572). Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

PHYSICS AND CHEMISTRY LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in nuclear physics, solid state physics, electro-optics, plasma physics, spectroscopy, and acoustics.

A 100-MeV electron linear accelerator with 5-microamp beam current is used in nuclear physics research as well as radiation effects studies. A 2-MeV Van de Graaff accelerator is also available for nuclear and atomic physics work.

The electro-optics laboratory uses imaging and detecting systems from the far infrared to the visible range including instrumentation for sea-going experiments in optical propagation. The laser laboratory contains a giant pulse laser and associated detection equipment for the visible spectrum as well as a high power laser in the IR region.

The plasma physics laboratory includes a plasma system, diagnostic equipment for studies of plasma dynamics, and a steady state plasma source with magnetic fields to 10,000 gauss.

The spectroscopy equipment includes a large grating spectrography, a large prism spectrograph, and an infrared spectrophotometer. The spectroscopic data center contains a comprehensive compilation of the known energy levels and atmoic spectral lines in the vacuum ultraviolet range.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test and wave tanks, and instrumentation for investigation in underwater

sound comprise the underwater acoustics laboratory.

The chemical laboratories provide facilities for undergraduate and graduate study and research in chemistry. Supporting these activities are: a molecular spectroscopy laboratory, including infrared, ultraviolet, and magnetic resonance (ESR and NMR) spectrometers; a chemical instruments laboratory with infrared and ultraviolet spectrophotometers, an atmoic absorption spectrophotometer, gas and liquid chromatographic equipment, and a vapor-phase osmometer; and a chemical dynamics laboratory with equipment for investigating photochemistry, rapid reaction kinetics, and chemical synthesis.

PHYSICS

PH 0110 REFRESHER PHYSICS (5-3). A six-week course designed to refresh incoming students, particularly allied Officers, in selected basic concepts of mechanics. The level of presentation and choice of material depend upon the background and needs of the students. The laboratory sessions are used to develop problem solving skills. *Noncredit.*

PH 0111 REFRESHER PHYSICS AND CHEMISTRY (7-3). A six-week refresher course of selected topics from elementary mechanics and chemistry for incoming students who are entering the more quantitative engineering and science curricula. Typical topics from mechanics are kinematics, Newton's laws, the concepts of energy, and momentum, and simple harmonic motion. Chemistry topics will include atomic structure, the chemical bond, stoichiometry, and chemical equilibrium and kinetics. The use of calculus and vector algebra is emphasized. The three one-hour laboratory periods are devoted to guided problem solving. PREREQUISITE: Previous college courses in elementary physics and chemistry and integral calculus.

PH 0499 ACOUSTICS COLLOQUIUM (0-1). Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: A course in acoustics.

PH 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

PH 0999 PHYSICS AND CHEMISTRY COLLOGUIUM (0-1). Discussion of topics of current interest and student thesis reports.

Lower Division Courses

The BASIC PHYSICS sequence, PH 1011, PH 1012, PH 1013, and PH 1014, comprises a series of courses equivalent to the standard university level introductory physics courses with calculus. Normally the student is expected to have adequate preparation in these areas at the time of matriculation at NPS; however these courses are available upon demand for students with partial or no background in basic physics.

The minicourses PH 1061 through PH 1067 comprise a Basic Physics sequence available in the self-instructional (PSI) mode for both on-campus and off-campus use. Various combinations of these minicourses are essentially equivalent to, and may be substituted for, the courses PH 1011, PH 1012, PH 1041, and PH 1051, as follows:

"classroom" courses	equivalent PSI sequence
PH 1011	PH 1061, PH 1062, PH 1063
PH 1012	PH 1064, PH 1065, PH 1066
PH 1041	PH 1061, PH 1062, PH 1064, PH 1065, PH 1066
PH 1051	PH 1061, PH 1062, PH 1063, PH 1067

BASIC PHYSICS LABS. Students requiring laboratory experience at this level should examine the course descriptions of PH 1300, which would normally be taken concurrently with PH 1012; PH 1400, which would normally be taken concurrently with PH 1013; and PH 1600, which would normally be taken concurrently with PH 1014.

PH 1011 BASIC PHYSICS I - MECHANICS (4-0). Vector algebra, particle kinematics in one and two dimensions; Newton's Laws; particle dynamics; work, kinetic and potential energy, conservation of energy; conservation of linear momentum; rotational kinematics and dynamics, conservation of angular momentum; oscillations; gravitation. PREREQUISITE: A course in calculus or concurrent registration in a calculus course.

PH 1012 BASIC PHYSICS II - ELECTRICITY

AND MAGNETISM (4-0). Electric charge, Coulomb's Law, Electric Field and Potential, Gauss's Law, Capacitors and Dielectrics, Current and Resistance, Simple Circuits, EMF, Magnetic Field, Ampere's and Faraday's Laws, Inductance, Electromagnetic Oscillations and Waves. Maxwell's Equations. PREREQUISITE: PH 1011 or equivalent.

PH 1013 BASIC PHYSICS III - FLUIDS, WAVES AND THERMODYNAMICS (4-0). Fluid states, conservation of matter, fluid dynamics, Bernoulli Equation; waves, sound waves, sonar equation; temperature, heat, internal energy, First Law of Thermodynamics; kinetic theory; entropy and second law of thermodynamics. PREREQUISITE: PH 1011, or equivalent. (PH 1012 is not a prerequisite for this course).

PH 1014 BASIC PHYSICS IV - OPTICS, ATOMIC AND NUCLEAR PHYSICS (4-0). Reflection and refraction; lenses and lens systems; optical devices; interference, diffraction; special relativity; quantum effects of waves and particles; structure of the hydrogen atom, introduction to wave mechanics, uncertainty principles; nuclear structure and nuclear reactions. PREREQUISITE: PH 1011 and PH 1012, or equivalent.

PH 1041 REVIEW OF MECHANICS AND ELECTRICITY AND MAGNETISM (5-1). First quarter of a sequence of fundamental physics for student in Electrical Engineering and Electronics. (The sequence includes PH 1041, 2241, 2641 and 3741). The subject matter of this course includes: kinematics, dynamics, conservation laws, electrostatics, Coulomb's and Gauss's laws, electric and magnetic fields, Ampere's and Faraday's laws, capacitance and inductance.

PH 1051 REVIEW OF VECTOR MECHANICS AND INTRODUCTION TO FLUIDS (4-2). Basic concepts of elementary vector mechanics, including; statics, motion in one dimension and in a plane, particle dynamics, energy, momentum, rotational dynamics, elementary properties of fluids, qualitative description of drag phenomena; turbulence and separation. The laboratory sessions are devoted to guided problem-solving. PREREQUISITE: Previous courses in general physics and calculus.

PH 1119 PHYSICAL SCIENCE REVIEW (2-0). A review course of six weeks duration designed for the Antisubmarine warfare curriculum. The course covers the use of coordinate systems and vectors, particle kinematics and dynamics, projectile motion, work and energy, and the harmonic oscillator.

PH 1300 BASIC ELECTRICITY AND MAGNETISM LABORATORY (0-2). An introductory laboratory for students who have had no previous experience with the fundamental experiments of electricity and magnetism. PREREQUISITE: Concurrent registration in PH 1012 desirable.

PH 1400 BASIC FLUIDS AND WAVES LABORATORY (0-2). An introductory laboratory for students who have had no previous experience with the fundamental experiments of fluid dynamics, wave motion, and acoustics. PREREQUISITE: Concurrent registration in PH 1013 desirable.

PH 1600 BASIC MODERN PHYSICS LABORATORY (0-2). An introductory laboratory for students who have had no previous experience with the fundamental experiments of modern physics. PREREQUISITES: PH 1300, concurrent registration in PH 1014 desirable.

PH 1901-1902 THE NATURE AND STRUCTURE OF PHYSICS I-II (4-2). The development of ideas and measurement leading from early models of the heavens through Galileo and Kepler to Newton and the Theory of Universal gravitation; satellites, natural and artificial; the concepts central to classical mechanics: momentum, kinetic and potential energies, conservation principles; questions about the nature of light; wave motion and wave properties of light. Fundamental concepts of electromagnetism and light as electromagnetic radiation; experiments with light and the crisis of classical physics; Einstein and Relativity; space and time revised, mass-energy equivalence; the question of atomic structure and the quantum interpretation; properties of atoms, nuclei, and particles.

Upper Division Courses

PH 2121-2122 APPLIED PHYSICS I-II (4-0). A two course sequence, intended for students of Operations Analysis, in which physical phenomena are described and illustrated by their application to situations of military interest. The first course con-

siders vibrating systems, resonance, the nature of sound and light, acoustics terminology and hearing, the eye and vision, the ray approximation, the ray treatment of propagation of acoustic and electromagnetic waves, geometric optics, the mathematical description of wave effects including transmission, reflection, standing waves, interference and diffraction. The second course considers electromagnetism, sources of electromagnetic radiation, the wave equation, phenomena associated with the interaction of waves and media including scattering and absorption, the mathematical description of nonrepetitive waveforms, modulation and bandwidth, noise and noise sources, infrared detectors, infrared systems, radar and sonar systems and the associated figure of merit equations.

PH 2123 BASIC PHYSICS (4-0). A course to provide physical background to wave motion, acoustics, electromagnetism, and optics for students in the Electronic Warfare curriculum and to provide applications of analytical techniques to physical problems. Areas covered are harmonic motion — differential equations, complex notation, damped vibration and resonance; wave motion — properties of waves, sound waves; electromagnetism — electrostatics, magnetostatics, electromagnetic waves, light; optics — geometrical optics, wave optics. PREREQUISITES: MA 2129, MA 3139 (may be concurrent).

PH 2151 MECHANICS I (4-0). Kinematics and dynamics in two and three dimensions. Projectile motion with drag; oscillations; two-body problem; rotating coordinate systems, Lagrangian mechanics; and fluid dynamics. PREREQUISITES: PH 1051, calculus, vector algebra, and concurrent registration for differential equations.

PH 2200 PHYSICS LABORATORY (0-4). A laboratory course emphasising measurement, uncertainty and error in experiments on geometrical optics and simple mechanical systems. Subjects to be covered include laboratory procedures, definition of measurement, random and systematic errors, propagation of uncertainties, graphical and analytical treatment of data, statistical concepts, focal length of lens and mirror, refractive index of glass, thick lens, optical instruments, optical spectra, the prism spectrometer. A laboratory text is required. PREREQUISITES: PH 1051 and ST 1810, PH 2265 taken concurrently.

PH 2241 WAVE PHENOMENA (4-0). Second quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. This course stresses the generality of wave phenomena drawing examples from optics, radar, acoustics, etc. Harmonic waves, interference, diffraction, wave equation, energy flow, boundary value problems and normal modes, Fourier analysis, Fourier transform phase and group velocity, geometrical optics. PREREQUISITES: PH 1041 or PH 1051.

PH 2251 WAVES AND PARTICLES (4-2). A course designed to provide the fundamental ideas of wave theory, physical optics, and introductory modern physics. The wave equation, interference, diffraction, polarization, Fourier transforms, group and phase velocity. The special theory of relativity. Photoelectric and Compton effects. Blackbody radiation. Bohr theory of the hydrogen atom, de Broglie hypothesis and an introduction to the Schroedinger equation. This course is available in PSI mode. PREREQUISITES: PH 1051, MA 2121 or equivalent.

PH 2260 OPTICAL PHYSICS (4-2). Wave and ray optics, optical instruments, wave propagation, interference, coherence, diffraction, polarization, and radiation sources. Laboratory: The laboratory sessions will be devoted to student performance of exercises designed to complement class discussions and to develop skills with optical instrumentation. PREREQUISITES: PH 1051, MA 1100 or equivalents.

PH 2261 INTRODUCTORY ELECTROMAGNETIC THEORY AND GEOMETRICAL OPTICS (4-0). The first of a three course sequence (PH 2261, PH 2251, PH 3361) for students of the Weapon Systems Technology Curriculum. The first portion of the course develops the concepts of electric and magnetic fields and how they are coupled to charge and current. The basic electromagnetic laws, leading to Maxwell's equations are developed. The influence of, and the effects on, materials is introduced (e.g. polarization, magnetization, dielectric constant, etc.). In the second portion of the course reflection, refraction, lenses mirrors and simple optical systems are discussed. PREREQUISITES: PH 1051 or equivalent, math through differential equations.

PH 2265 GEOMETRICAL OPTICS (2-2). The first course of a three course sequence emphasizing

a system oriented viewpoint for students in the Weapons Systems Science curriculum. The course first introduces geometrical optics; reflection and refraction of rays at plane and spherical surfaces; mirrors, plane and spherical; lenses; thick lenses and lens aberration; matric methods for thick lenses and lens systems. The transfer function of the optical system is then compared and contrasted with the transfer function and state variable methods of electrical systems analysis. PREREQUISITES: A basic course in mechanics, and mathematics through linear algebra and calculus. Students should be simultaneously registered for differential equations. Students must present a basic electrical engineering course such as EE 2107, EE 2104 and EE 2105.

PH 2270 FUNDAMENTALS OF ELECTRO-OPTICS (4-0). This course is designed to provide specific background material needed for an understanding of electro-optics. This material is in the general areas of advanced optics, atomic physics, solid state physics, and lasers. In more detail, the areas are catadioptric systems, matrix optics, gaussian profile beams, Fourier optics, resolution, atmospheric transmission, atomic and molecular energy states, line shapes, electrons in solids, band theory, photoconduction, p-n junction photocells, light emitting diodes, optical materials, stimulated emission, laser pumping, laser types, high energy lasers. PREREQUISITES: MA 3139, PH 2123.

PH 2280 NUCLEAR WEAPONS AND FOREIGN POLICY (4-0). An interdisciplinary course which covers both the technology and political influences of nuclear weapons systems. The course will emphasize the interaction of nuclear weapons systems with the foreign policies of the major powers and political blocs from 1945-present.

PH 2351-2352 ELECTROMAGNETISM I-II (4-1) and (4-0). Properties of electric and magnetic fields and the development of Maxwell's Equations (for static fields); electrostatic fields and potential in free space and dielectrics, the magnetic fields and potentials of steady currents in free space and permeable materials, electromagnetic induction, Maxwell's Equations, and Poynting's Theorem. Faraday's law and the general Maxwell equations; properties of electromagnetic waves: wave equations; propagation of plane waves in free space, dielectrics, conductors, and plasmas; reflection and refraction of plane waves; two-conductor transmission lines; rectangular wave guides. PREREQUISITES: PH 1051 and MA 2161 or equivalent.

PH 2471 INTRODUCTION TO THE SONAR EQUATIONS (3-0). A discussion of each term of the sonar equation with application to the detection, localization, and classification of underwater vehicles. This course is intended primarily for the students in the Antisubmarine Warfare curriculum. PREREQUISITES: Pre-calculus mathematics.

PH 2552 INTRODUCTION TO THE THERMAL AND DYNAMIC PROPERTIES OF GASES AND LIQUIDS (3-0). Introductory thermodynamics including the First and Second Laws, properties of gases and liquids, basic fluid mechanics including equations of motion in both inertial and non-inertial coordinate systems. This course is designed for the ASW curriculum. PREREQUISITES: Courses in vector calculus and differential equations (may be taken concurrently).

PH 2600 PHYSICS LABORATORY II (0-4). A laboratory course emphasizing measurement, uncertainty and error in experiments on physical optics and atomic physics. Experiments will be chosen to illustrate the fundamentals of wave interference, diffraction, fundamental constants of physics, the wave-particle duality, and the quantization of radiation. PREREQUISITES: PH 2200; PH 2351; PH 2251 and PS 2350.

PH 2641 ATOMIC PHYSICS (4-2). Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Bohr model. Schroedinger equation, exact solution for hydrogen atom, electron spin, periodic table, atomic spectra, transition probabilities, Einstein coefficients and stimulated emission, molecules and molecular spectra. PREREQUISITES: PH 2241 and PH 2251.

PH 2810 SURVEY OF NUCLEAR PHYSICS (4-0). A course designed to introduce the student to the ideas of nuclear physics, with emphasis on neutron physics and reactors. Atomic nature of matter; wave-particle duality; the nuclear atom. Basic nuclear properties; reactions; neutrons and fission. Reactors.

PH 2903 PHYSICS AND MODERN DEVICES (3-2). Development of the physical foundations of some recent technological devices of interest to the

Naval Officer. The topics will be selected according to the interests of the class and instructor and could include items such as lasers, magnetometers, underwater detection, nuclear fission and fusion, solid state electronics. PREREQUISITE: PH 1902 or consent of the Instructor.

Upper Division or Graduate Courses

PH 3152 MECHANICS (4-0). This course consists of advanced topics in intermediate mechanics: the anharmonic oscillator and variational methods; collisions and scattering; rigid body dynamics; coupled oscillators and classical pertubation theory. PREREQUISITE: PH 2151.

PH 3154 PHYSICS OF SPACE VEHICLE DYNAMICS (3-0). Basic physical principles are applied to study the trajectories of satellites and missiles: orbits in the inverse-square force field are developed, including the role of initial (launch) conditions, followed by rendezvous problems, transfer between orbits, synchronous satellites, perturbations due to oblateness of the earth. An introduction to launch and re-entry problems is given, including multistage rockets. Advanced propulsion methods. PREREQUISITES: PH 2152 or equivalent mechanics course.

PH 3157 PHYSICS OF CONTINUA (4-0). The continuum hypothesis. Cartesian tensors. The concept of stress. Deformation. Conservation of mass, momentum and energy. Theory of constitutive equations. Applications to fluid mechanics, solid mechanics and wave phenomena. PREREQUISITE: PH 2151.

PH 3161 PHYSICS OF UNDERWATER VEHICLES (4-1). Physical properties of liquids. Solutions to potential flow problems. Viscous flow; the laminar boundary, turbulence, and separation. Cavitation. Special topics may include: hydrodynamic noise, resistance of surface ships, and drag reduction techniques. PREREQUISITES: Vector calculus (e.g., MA 2161), and mechanics (e.g., PH 1051).

PH 3271 ELECTRO-OPTIC PRINCIPLES AND DEVICES (4-0). This course is designed to provide the student with an understanding of the principles of operation of the components that make up electro-optic systems. The general areas to be included are atmospheric transmission, nonlinear optics, detectors and displays. All wavelength ranges in which the atmosphere transmits will be treated, from ultraviolet to the far infrared. In more detail, the material will include thermal blooming, adaptive optics, EO signatures, EO modulators and shutters, beam steerers, detectors, cooling, imaging detectors for low light level TV and FLIR, CCD's and CID's image storage and display. PREREQUISITES: PH 2270, MR 2416.

PH 3280 ELECTRO-OPTICS (4-2). Refracting systems; atmospheric and underwater transmission, scattering, and scintillation; diffraction and Fourier transform methods; coherent optics. Fourier plane filters, holography; fiber and film optics; electroptic detectors; infrared techniques; image intensifiers; lasers and applications; nonlinear optics.

PH 3281 NON-ACOUSTIC SENSOR SYSTEMS (4-0). A course for the ASW curriculum. The purpose is to expose the technology and engineering of various systems important in antisubmarine warfare operations which involve non-acoustic sensing methods. Systems to be discussed include passive and active electronic warfare. Echo ranging, field distortion, image systems, communications and telemetry, proposed systems. The systems approach implies a consideration of environmental effects. PREREQUISITES: EE 2721, PH 3360, EE 3714, SECRET clearance.

PH 3360 ELECTROMAGNETIC WAVE PROPAGATION (4-1). This condensed one quarter introduction to electromagnetic theory is designed to serve specific needs in the engineering acoustics, weapon systems technology, and ASW curricula. After an analytical introduction to electromagnetic field theory, the course concentrates on properties of electromagnetic wave propagation and the phenomena of radio and radar transmission, including special topics on antennas and wave guides. PREREQUISITES: MA 2161, MA 3132, and a course in general physics.

PH 3361 ELECTROMAGNETIC WAVE PROPAGATION (4-0). The third course in the sequence (PH 2261, PH 2251, PH 3361) for the Weapon Systems Technology Curriculum. Propagation of electromagnetic waves and pulses, reflection, refraction, scattering. Impedance of media, absorbing media, impedance matching. Coatings and filters. Transmission lines, waveguides. PREREQUISITES: PH 2261, PH 2251.

PH 3431 PHYSICS OF SOUND IN THE OCEAN (4-2). A survey of physical acoustics with emphasis on the generation, propagation, and detection of sound in the ocean, primarily for students in the Environmental Science and Operations Analysis Curricula. Topics include: damped and forced harmonic oscillations; the acoustic wave equation and its limitation in fluids; solutions for plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation in the ocean; effects of inhomogeneities and sound absorption; term by term analysis of the SONAR equations emphasizing transmission loss models and detection threshold models; properties of transducers for underwater sound. Laboratory experiments include surface interference, spectral analysis of noise, normal modes, waveguides, and acoustical sources. PREREQUISITES: A course in general physics and a course in differential equations and complex exponential notation.

PH 3432 ELEMENTS OF PHYSICS OF SOUND IN THE OCEAN (3-0). This course is a shortened version of PH 3431 for students of the Curriculum 373. PREREQUISITES: A course in general physics and a course in differential equations and complex exponential notation.

PH 3451 FUNDAMENTAL ACOUSTICS (4-1). Mechanics of free, forced, and damped simple vibratory systems. Mechanical impedance. Development of, and solutions to the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Acoustical behavior of sources and arrays. Radiation impedance. Introduction to transducers. Laboratory experiments on selected topics. PREREQUISITES: A course in mechanics (e.g., PH 1051); Differential Equations (e.g., MA 2121).

PH 3452 UNDERWATER ACOUSTICS (4-2). Lumped acoustic elements and propagation in pipes. Steady state response of acoustic waveguides. Group and phase speeds. Normal modes. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean; the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems. Laboratory experiments on selected concepts. PREREQUISITE: PH 3451.

PH 3458 NOISE, SHOCK AND VIBRATION CONTROL (4-0). The application of the principles of acoustics and mechanics to the problems of controlling noise, vibration and mechanical shock. Topics include: Linear mechanical vibrations, introduction to vibrations of non-linear systems; damping mechanisms; vibration and shock isolation; noise generation and control; effects of noise on man; application to problems of Naval interest such as ship quieting and industrial noise control. PREREQUISITE: A course in acoustics.

PH 3461 EXPLOSIVE SHOCK WAVES (4-0). Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Damage mechanism and principles of protection against damage. PREREQUISITES: PH 2551 or CH 2401, and PH 2151 or PH 3451.

PH 3463 SPECIAL TOPICS IN UNDERWATER ACOUSTICS AND SOUND (3-2). Special topics of interest in the areas of underwater sound, transduction, propagation and detection, depending on the interests and needs of the students. PREREQUISITE: A course in acoustics, i.e.: PH 3431, 3451, or 3452.

PH 3472 UNDERWATER ACOUSTICS (4-2). In this course, the second of a three-course sequence for students in the ASW curriculum, an analytical study is made of the underwater acoustics that affect the sonar equation. Topics include: the wave equation and ray acoustics; acoustic properties of fluids; plane, spherical, and cylindrical waves; behavior of sources and arrays; reflection and transmission at boundaries; image theory; propagation in wave guides; and normal mode propagation in the ocean. This course is taught in coordination with OC 3265. PREREQUISITES: PH 3471 and concurrent enrollment in OC 3265.

PH 3551 THERMODYNAMICS (4-1). Fundamental theory of thermodynamics and applications to physical systems. First and second laws of thermodynamics; entropy; thermodynamic potential; applications to gases, liquids, radiation, and magnetic materials; equilibrium. PREREQUISITES: PH 1051 and calculus of several variables.

PH 3561 INTRODUCTORY STATISTICAL PHYSICS (4-0). Distribution functions, kinetic theory, transport processes, introduction to classi-

cal and quantum distributions. Applications to gases, solids, and radiation. PREREQUISITES: PH 2152, PH 2551, or CH 2401, PH 3651.

PH 3600 PHYSICS LABORATORY (0-4). A laboratory course emphasizing the measurement and data handling techniques of modern physics as applied to experiments in the area of atomic physics. Subjects to be investigated experimentally include: atomic spectroscopy, interferometry, mass spectra, ionization potentials, the Zeeman effect, electron diffraction, gas laser and plasma phenomena. The techniques of data analysis developed in PH 2200 and PH 2600 will be applied to the experimental data. A laboratory text is required. PREREQUISITES: PH 2600, PH 3651 to be taken concurrently.

PH 3651 ATOMPIC PHYSICS (4-2). Wave mechanics: free states; barrier penetration; square well; hydrogen atom, energy levels and angular momentum. Historical material on atomic structure and spectra. Electron spin. Exclusion principles and periodic table. Vector model, sodium atom, spectra of selected atoms. Zeeman effect. X-rays. Transitions, Einstein coefficients, lasers. PREREQUISITES: PH 2251 and MA 2161 or equivalent.

PH 3652 ELEMENTS OF MOLECULAR AND SOLID STATE PHYSICS (4-0). Bonds between atoms, crystals, conduction in solids, band theory, semiconductors, p-n junctions devices; quantum mechanics in the Schroedinger and Dirac approaches applied to various problems in solid-state and molecular physics. PREREQUISITES: PH 3651.

PH3687 PHYSICS OF ELECTRON INTERACTION IN GASES (3-0). This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer emission from surfaces, recombination high frequency d c and laser breakdown, sheaths, the glow and arch discharges, radiation, application to the gas laser. PREREQUISITES: PH 2641 or PH 3651 or consent of the Instructor.

PH 3741 ELECTRONIC PROPERTIES OF METALS AND SEMICONDUCTORS (4-2). Fourth course in the sequence of fundamental physics for students in Electrical Engineering and Electronics. (PH 1041, PH 2241, PH 2641) Crystals and lattice properties, X-ray diffraction, free-elective mass, holes, intrinsic and impurity semiconductors, diodes, transistors, thermoelectric effects, minority carriers, modern devices. PREREQUISITES: PH 2641 or PH 3651.

PH 3900 ADVANCED PHYSICS LABORATORY (0-3). This laboratory course provides entry into specialty areas of experimental physics. Experiments will be conducted as projects assigned on an individual basis in such areas as modern optics, electro-optics, electron resonance, plasma physics, nuclear physics and properties of solids. Modern experimental techniques will be stressed. PREREQUISITES: PH 3600 and PH 3652.

PH 3951 QUANTUM MECHANICS (4-0). Applications of quantum mechanics to phenomena in atomic, molecular, and solid-state physics, angular momentum. Spin states of hydrogen Spin-orbit coupling and Zeeman effect. Variation methods and perturbation theory. Electronic structure of atoms and molecules. Molecular and chemical lasers. Molecular vibrations and rotations. Raman effect. Group theory. PREREQUISITES: PH 3652.

PH 3998 SPECIAL TOPICS IN INTERMEDIATE PHYSICS (1-0 to 4-0). Study in one of the fields of intermediate physics and related applied areas selected to meet the needs of the student. The course carries a letter grade and may be repeated in different topics. PREREQUISITE: Consent of the Department Chairman.

PH 3999 READING IN INTERMEDIATE PHYSICS (1-0 to 4-0). Supervised reading in one of the fields of intermediate physics selected by students to meet special interests. The course carries a pass-fail grade. PREREQUISITE: Consent of the Instructor.

Graduate Courses

PH 4162 FLUID MECHANICS (3-0). An advanced study of the physical bases of fluid mechanics: Fundamental concepts of continuum mechanics. Fluid mechanical models. Theory of hydrodynamic stability. Lighthill's theory of aerodynamically produced sound. Effects of compres-

sibility. PREREQUISITE: A course in hydrodynamics (e.g., PH 3161).

PH 4171 ADVANCED MECHANICS (4-0). Hamilton's Principle. The equations of motion in Lagrangian and Hamiltonian form. The inertia tensor and rigid bodies. Canonical transformations and Poisson brackets. Small oscillations. Additional topics as time allows; Hamilton-Jacobi theory, perturbation theory. PREREQUISITES: PH 2152, PH 2352.

PH 4281 ELECTRO-OPTIC DEVICES (4-0). Infrared, visible and ultraviolet detectors and their limitations; electron optical devices; scanning devices; image displays and storage techniques; starlight viewing devices; viewing devices for self-luminous infrared sources; optical tracking; lasers and applications; coherent optical information processing and holography; nonlinear optical devices; optical heterodyning; acoustic-optic devices; fiber and film optical devices; optical signal processing and switching. PREREQUISITES: PH 3280 and a corequisite course in solid state physics.

PH 4283 LASER PHYSICS (4-0). The physics of lasers and laser radiation. Topics will include: quantum and semi-classical oscillator model, gain; Gaussian beams, stable and unstable resonators; rate equations, output coupling, mode locking, short pulsing; specifics of solid state, and gas laser systems; semiconductor lasers; high energy lasers; amplifiers and laser systems for fusion research; laser-surface interaction air breakdown, LSC and LSD waves. PREREQUISITES: PH 3652 or equivalent; or consent of Instructor.

PH 4353 ELECTROMAGNETISM III (4-0). Classical radiation theory: retarded potentials, Lienard-Wiechert potentials, fields of a fast electron, angular distribution and frequency spectrum of radiation from an accelerated point charge. Cherenkov radiation, Hertz potentials and dipole radiation, and radiation from linear antennas. PREREQUISITES: PH 2352.

PH 4363 THEORY AND APPLICATIONS OF WAVES IN RANDOM MEDIA (4-0). In this last of the three course sequence in Electromagnetism (PH 2351, PH 2352, PH 4363) the topics of study are: scattering and absorption of waves by single particles, multiple scattering and radiation transport through medium of random scatterers, propagation and scattering of waves in a turbulent continuous medium. PREREQUISITES: PH 2352, MA 3132 or similar.

PH 4371 CLASSICAL ELECTRODYNAMICS (3-0). Tensors in special relativity. Classical relativistic electromagnetic field theory. Lorentz electron theory. PREREQUISITES: PH 4353 and familiarity with the special theory of relativity and Lagrangian mechanics.

PH 4400 ADVANCED ACOUSTICS LABORATORY (0-6). Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4453 RADIATION AND SCATTERING OF WAVES IN FLUIDS (4-0). An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields, incoherence and coherence; applications of the Helmholtz integral, probability density functions, correlations and frequency spectra of sound scattered from rough boundaries. PREREQUISITE: PH 3452 or consent of Instructor.

PH 4454 TRANSDUCER THEORY AND DESIGN (3-2). A treatment of the fundamental phenomena basic to the design of transducers for underwater sound and specific examples of their application. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory experiments on measurement techniques, properties of transducer materials and characteristic of typical transducer types. PREREQUISITE: PH 3452.

PH 4456 SEMINAR IN APPLICATIONS OF UNDERWATER SOUND (3-0). A study of current literature on applications of acoustics to problems of Naval Interest. PREREQUISITE: PH 4453 or consent of Instructor.

PH 4459 SHOCK WAVES AND HIGH-INTENSITY SOUND (3-0). A study of the physics of shock wave phenomena with emphasis on acoustics, such as sonic booms and underwater explosions; the development of the nonlinear acoustic wave equation and its application to intense sound propagation, such as the parametric generation and detection of sound; and selected topics in large amplitude sound of mutual interest to the students and the instructor.

PH 4473 ADVANCED TOPICS IN UNDERWA-

TER ACOUSTICS (4-0). The last in a sequence of courses in acoustics designed for students in the ASW curriculum (PH 2471, PH 3472, PH 4473). Topics to be studied, selected on the basis of interests of the students and the instructor, may include: transducers for underwater sound, including parametric arrays; physics of realistic transmission loss models, including fluctuations in the properties of the medium and boundaries and their effects on reverberation, transmission loss, array gain and signal detectability; reflection from visco-elastic boundaries and realistic sea-floor models; noise and vibration control aboard ship; sound absorption processes. PREREQUISITE: PH 3472 or consent of instructor.

PH 4571-4572 STATISTICAL PHYSICS I-II (3-0). Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble theory, microcanonical, canonical and grand canonical ensembles, quantum statistics. Applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. PREREQUISITES: PH 2152, 3651, 2551.

PH 4630 SPACE PHYSICS I-PHYSICS OF THE UPPER ATMOSPHERE (4-0). Structure of the upper atmosphere. Atmospheric absorption in the infrared, visible and ultraviolet. The ionosphere. Geomagnetic field and the radiation belts. Disturbances of the upper atmosphere. Magnetic field, the magnetopause and solar wind. Experimental instrumentation in space research. PREREQUISITES: PH 2352 and PH 3652 or consent of the Instructor.

PH 4631 SPACE PHYSICS II-INTRODUCTION TO ASTROPHYSICS (4-0). Introduction to theories of stellar interior, energy transport in stars, and stellar evolution. PREREQUISITES: Consent of Instructor.

PH 4661 PLASMA PHYSICS I (4-0). This course constitutes a broad study of the behavior and properties of gaseous plasma, the fourth — and most abundent — state of matter in the universe. Plasma physics is a vigorously developing branch of contemporary physics. Its many applications are in areas such as astro- and space-physics, atomic physics, magnetohydrodynamic power generation, electron beam excited laser, laser isotope enrichment, ionospheric communication, and thermonuclear fusion. The physical concepts fundamental to various branches of plasma physics are introduced. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The magnetohydrodynamic and the two-fluid plasma models are considered. PREREQUISITES: PH 2352, PH 3561, PH 3651, or the equivalent.

PH 4662 PLASMA PHYSICS II (3-0). A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the study of macroscopic motions of plasma. Equilibrium and stability. Classification of plasma instabilities. Kinetic theory, the Boltzmann equation and the macroscopic momentum transport equation. Plasma oscillations and Landau damping. Nonlinear effects, shock waves, Radiations from plasma, including bremsstrahlung and cyclotron radiation. Controlled fusion and laser produced plasmas. PREREQUISITES: PH 4353, PH 4661 or equivalent.

PH 4681 ADVANCED PLASMA PHYSICS (3-0). Selected topics in plasma physics, such as laser-target interaction, dynamics of a laser-produced plasma, self-generated magnetic fields, light scattering and absorption in plasma, turbulence and fluctuations, collisionless shock waves. PREREQUISITES: PH 4662 or consent of the Instructor.

PH 4685 ADVANCED ATOMIC PHYSICS (3-0). Selected topics in atomic spectroscopy and atomic collisions. Classical and quantum description of the collision process, transition probabilities and line broadening mechanisms. PREREQUISITES: PH 3651 and consent of the Instructor.

PH 4750 RADIATION EFFECTS IN SOLIDS (4-2). Energy loss of radiations in matters, radiation dosimetry, energy transfer of radiation to matter, theory and spectra of radiation from nuclear weapons, fireball development, electromagnetic pulse phenomena, displacements of atoms in solids, radiation damage to solid-state devices. PREREQUISITE: PH 3652.

PH 4760 SOLID STATE PHYSICS (4-2). Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism.

PREREQUISITES: PH 3651 and PH 3561 (the latter may be taken concurrently).

PH 4790 THEORY OF QUANTUM DEVICES (3-0). Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, amplifiers, magnetic instruments. PREREQUISITE: PH 2641 or PH 3651.

PH 4851 NUCLEAR PHYSICS I (4-0). Nuclear decay schemes and energetics; nuclear forces; the deuteron and low energy nucleon-nucleon scattering; partial wave and analysis of scattering; neutron-induced reactions and the Breit-Wigner formula; beta and gamma Decay; and Q-value in reactions. PREREQUISITES: PH 3652, PH 3951 and PH 2352.

PH 4881-4882 ADVANCED NUCLEAR PHYSICS I-II (3-0). Relativistic mechanics, scattering of electronics from nuclei, nuclear models, nuclear potentials. Relativistic treatment of the electron using the Dirac equation and application to electron scattering to develop the Mott cross-section; treatment of form-factors arising from electron-nucleon and election-nucleus scattering; application of electron scattering to study the structure of nucleon matter and the study of nucleon models. PREREQUISITE: PH 4851.

PH 4885 REACTOR THEORY (3-0). The diffusion and slowing down of neutrons. Homogeneous thermal reactors; time behavior; reactor control. Multigroup theory. Heterogeneous system. PREREQUISITES: PH 4851 or equivalent.

PH 4900 INTRODUCTION TO EXPERIMENTAL RESEARCH (0-3). This course is a continuation of PH 3900. Attention is normally concentrated upon instrumentation, techniques and analysis appropriate to the student's thesis. PREREQUISITE: PH 3900.

PH 4971-4972-4973 QUANTUM MECHANICS I-II-III (3-0). General principles of nonrelativistic quantum mechanics; stationary states. Addition of angular momenta; time-independent and time-dependent perturbation theory; scattering theory; identical particles and spin. General principles of relativistic quantum mechanics; properties and solutions of relativistic wave equations. PREREQUISITES: PH 3651, 4171.

PH 4981-4982 QUANTUM FIELD THEORY I-II (3-0). General principles of quantum field theory; quantization of scalar, spinor, and electromagnetic fields. Interacting fields; the S-matrix and renormalization; strong, electromagnetic, and weak interactions; introduction to dispersion relations. PREREQUISITE: PH 4973.

PH 4991 RELATIVITY AND COSMOLOGY (3-0). Einstein's general theory of relativity. The three classical tests. The Schwarzschild singularity and black holes. Cosmological models and their relations with observations. Introduction to modern developments: gravitational waves, Dicke's theory, problems of quantum cosmology and superspace. PREREQUISITE: PH 4371.

PH 4993 PHYSICAL GROUP THEORY (3-0). Invariance of quantum mechanical systems to certain groups of transformations. Topics are selected from finite rotation groups and crystal symmetries, the continuous rotation group in three dimensions, transformation groups associated with elementary particle symmetries. PREREQUISITE: PH 4972.

PH 4998 SPECIAL TOPICS IN ADVANCED PHYSICS (1-0 to 4-0). Study in one of the fields of advanced physics selected to meet special needs of the students. PREREQUISITE: Consent of the Department Chairman.

PH 4999 ADVANCED SEMINAR (1-0 to 3-0). A seminar or supervised reading in recent developments in basic and applied physics and related areas. May be conducted by faculty members with student participation. PREREQUISITES: Student should have graduate standing and the consent of the instructor. Graded on Pass/Fail basis only.

CHEMISTRY

Lower Division Courses

CH 1001-1002 INTRODUCTORY GENERAL CHEMISTRY I-II (4-2) and (3-2). A two-quarter sequence for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter. Practical applications of chemical principles.

Upper Division Courses

CH 2001 GENERAL PRINCIPLES OF CHEMISTRY (3-2). A study of the fundamental principles

of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter and chemical equilibria. Special attention is given to the compounds of carbon. Elementary phÿsical chemistry experiments are performed in the laboratory. PREREQUISITE: College Chemistry.

CH 2010 INORGANIC ANALYSIS (3-3). A continuation of CH 2001. Computations involving acid-base, solubility, and complex ion equilibria. Principles of quantitative analysis. Descriptive inorganic chemistry. Laboratory work will consist of gravimetric and volumetric analysis. PREREQUISITE: CH 2001 or CH 1002.

CH 2102 INORGANIC CHEMISTRY (3-3). Redox reactions and the electrode potential. Introduction to reaction mechanism. Bonding in inorganic species. Acids and bases. Laboratory will make use of qualitative, semi-quantitative, and instrumental methods to study the principles further, especially as applied to the solution chemistry of the metals. PREREQUISITES: CH 2101 and CH 2402.

CH 2201 CHEMICAL INSTRUMENTS (3-3). A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. PREREQUISITES: CH 2101 and CH 2403.

CH 2301-2302 ORGANIC CHEMISTRY I-II (4-3) and (3-). The chemistry of organic compounds. Emphasis in the laboratory on synthetic techniques.

CH 2401 CHEMICAL THERMODYNAMICS (4-1). The laws of thermodynamics and their applications to chemical systems. Use is made of the chemical potential in describing multicomponent systems and the conditions for thermodynamic equilibrium. PREREQUISITE: Differential Equations.

CH 2402-2403 PHYSICAL CHEMISTRY I-II (4-2) and (4-3). A continuation of the subject matter of CH 2401 covering chemical equilibrium and kinetics, electrochemical cells, kinetic theory of gases and introductory atomic and molecular structure.

CH 2910 INTERACTION OF NAVAL OPERATIONS AND ENVIRONMENTAL POLLUTION (4-0). An interdisciplinary course which examines the impact of environmental pollution on Naval operations by examining current technical status, future plans for abatment, and the resultant limitations placed on Naval facilities, especially ships. The course will consider air, water, nuclear, and noise pollution or the potential for pollution as appropriate. PREREQUISITES: Math through college algebra. Two quarters of physical science or biology within the last two years is desirable.

Upper Division or Graduate Courses

CH 3101 ADVANCED INORGANIC CHEMISTRY (3-3). Coordination compounds and crystal field theory. Inorganic reaction mechanisms. The laboratory introduces the student to general methods for investigating chemical reaction. PREREQUISITES: CH 2101, CH 2403.

CH 3301 PHYSICAL ORGANIC CHEMISTRY (3-0). First quarter of a two-quarter sequence. In this term the tools available for the study of organic mechanisms are discussed and appropriate examples used. PREREQUISITES: CH 2302, CH 3101.

CH 3402 PHYSICAL CHEMISTRY IN ORDNANCE SYSTEMS (4-2). A course in topics of special interest to students in Ordnance Engineering. Thermochemistry, chemical equilibrium, chemical kinetics, electrochemistry. Applications will include problems in explosives and propellants, corrosion, fuel cells, remote sensors, and environmental effects. The laboratory will amplify the lecture material especially through the use and study of chemical instruments. PREREQUISITES: PH 2551; a previous course in chemistry.

CH 3403 CHEMICAL THERMODYNAMICS (3-0). Application of thermodynamics to ideal and to real gases, non-electrolyets, electrolytic solutions, multicomponent solutions. Calculations of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and

other molecular data. PREREQUISITES: Physical chemistry, elementary thermodynamics.

CH 3405 MOLECULAR DYNAMICS (5-0). Direct application of the Schroedinger wave equation to the hydrogen atom, angular momentum, matrix formulation of quantum mechanics, electron spin, the Pauli principle, interaction with electromagnetic radiation, development of group theory and application in quantum mechanics, and application of preceding framework to molecular hydridization, molecular orbital theory, ligand field theory, and vibrational spectra. PREREQUISITES: CH 2403, Matrix algebra.

CH 3415 STATISTICAL MECHANICS (4-0). A general treatment of the principles of quantum and classical statistical mechanics with applications to chemical systems. Included are distribution laws and the relationships of Fermi-Dirac, Bose-Einstein, and corrected Boltzmann statistics, statistical entropy and thermodynamic functions for corrected Boltzmann statistics; applications to chemical equilibria. diatomic and polyatomic molecules including ortho and para hydrogen; canonical and grand canonical ensembles; real gases. PREREQUISITES: CH 2403.

CH 3761 EXPLOSIVES TECHNOLOGY (4-0). Characteristics and terminology applied to explosives and propellants, manufacture and fabrication of explosives and explosive devices, detonics, thermochemical, and chemical kinetics of detonations. PREREQUISITES: PH 2551, CH 2402, and MS 2201 or equivalent.

Graduate Courses

CH 4302 PHYSICAL ORGANIC CHEMISTRY II (3-0). The techniques discussed in CH 3301 are used in the study of organic reaction mechanisms as currently understood. PREREQUISITE: CH 3301.

CH 4406 QUANTUM CHEMISTRY (3-0). A study of molecular spectra and molecular electronic structure, emphasizing theory, interpretation, and prediction of spectra utilizing the quantum mechanical formulation. PREREQUISITE: CH 3405.

CH 4410 CHEMICAL KINETICS (3-0). Experimental methods and interpretation of data. Collision theory and activated-complex theory. Mechanisms of reactions. PREREQUISITES: CH 2403 and consent of Instructor.

CH 4505 RADIATION CHEMISTRY (3-0). A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. PREREQUISITE: CH 2403 or the equivalent.

CH 4800 SPECIAL TOPICS (2-0 to 4-0). Pursuit of deeper understanding of some topic chosen by the student and the instructor; may involve directed reading and conference or a lecture pattern. May be repeated for credit with a different topic. PREREQUISITE: Consent of the Department Chairman.

OTHER COURSES

SE 2001 through SE 4006 are a series of courses specifically designed for students in the Naval Intelligence Curriculum (825).

Upper Division Courses

SE 2001 ENVIRONMENT, WAVE PROPAGATION AND OCEAN SYSTEMS (4-0). This is the first course of a five course sequence designed for the Naval Intelligence Curriculum to introduce the concepts of military technology. In this course, basic concepts of environmental science are reviewed and related to environmental data networks, environmental effects upon the propagation of acoustic and electromagnetic waves are studied, fundamentals of acoustic surveillance systems are developed, and current capabilities are discussed.

SE 2002-2003 CONCEPTS OF SCIENCE AND ENGINEERING I-II (4-0). A two course sequence designed to prepare an advanced student with a non-quantitative and non-technical background for the study of advanced technology systems. Topics include: linear systems modeling and characteristics, spectral analysis, wave properties and wave phenomena, and computer systems; photography and photogrammetry, communication systems, signal processing, and control systems. PREREQUISITE: Mathematics including an introduction to differential and integral calculus.

SE 2279 DIRECTED STUDIES IN SCIENCE

AND ENGINEERING (Credit open). Independent study in science and engineering topics in which formal course work is not offered. PREREQUISITE: Permission of Department Chairman. (Graduate student register for SE 3279).

Upper Division or Graduate Courses

SE 3004-3005 SURVEY OF MILITARY TECHNOLOGY: CONCEPTS AND APPLICATIONS I-II (4-0). A two course sequence designed to familiarize the student with the conceptual basis of military applications of technology. The first course treats communications systems, radar systems, electronic surveillance systems and electro-optics systems. The second treats strategic systems, satellite systems, missile systems, selected topics in aeornautical and naval engineering, and acoustic surveillance systems. PREREQUISITES: SE 2003, or equivalent, and SECRET clearance (NOFORN).

SE 3279 DIRECTED STUDIES IN SCIENCE AND ENGINEERING (Credit open). (See SE 2279).

Graduate Course

SE 4006 SPECIAL TOPICS IN TECHNOLOGY ASSESSMENT (4-0). Methods by which the technological capabilities of a nation, either current of future, will be assessed. Problems in source evaluation, cross-impact analysis, and trend extrapolation. Delphi studies and their role. As a part of this seminar, the student will make a detailed study and report on the methodology and results of a current technology assessment study. Content will vary, depending upon availability of material and the current interests of the professor and students. PREREQUISITES: SE 3004, SE 3005, and SECRET clearance (NORFORN).

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

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ROBERT von PAGENHARDT, Professor (1967); A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., 1970.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

The Navy Management Systems Center, a jointly staffed DoD sponsored activity, was established as a separate Naval Activity in February 1966. As of 1 July 1974 the name was changed to Defense Resources Management Education Center. It conducts both resident and on-site defense resource management courses for U.S. and international military personnel of all services in grades 0-4 and above and military-related civilians of equal grades. The focus of all programs conducted by the Center is on the development of knowledge and improvement of understanding of the concepts, techniques and application of modern defense management systems, with specific emphasis on effective resource management.

The Center currently offers a four-week U.S. Defense Management Systems Course eight times each year, a one-week Flag/General Defense Management Course twice each year, a thirteen-week International Defense Management Course twice each year, a four-week Senior International Defense Management Course one time each year (similar to the 13-week international course but contracted). In addition to the DoD programs, the Center is currently involved in presenting management programs on-site to the service components and selected governments.

Since 1966, the Center has graduated over 10,000 students.

Faculty members of the Center are a part of the regular faculty of the Postgraduate School.

DEFENSE MANAGEMENT SYSTEMS COURSE

The Planning-Programming-Budgeting System as developed since 1961 by the Office of the Secretary of Defense has provided a framework for examining various force mixes, allocation of resources, and relationships to military capabilities.

The objective of the Defense Management Course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of management, including requirement studies, systems analysis cost/effectiveness, cost estimating and analysis.

Students are not expected to become experts or technicians in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analyses for decision-

making, understanding of the principles, methods and techniques used, and awareness of the interfaces between management and requirements of the Department of Defense components and the Office of the Secretary of Defense

FLAG/GENERAL DEFENSE MANAGEMENT COURSE

The Flag/General officer course examines Defense Management problems of strategy implementation and operations with a view towards developing knowledge and understanding of the concepts, principles, processes, applications and techniques of Defense Management Systems (i.e., planning, programming, budgeting and related activities). No specific attempt is made to further develop technical skills required in each of the planning, programming, and budgeting activities.

INTERNATIONAL DEFENSE MANAGEMENT COURSE

The course is designed for participants in the military grades of 0-4 (Major/Lieutenant Commander) through 0-6 (Colonel/Captain) and defense-related civilians of equivalent rank. Enrollment is currently limited to a maximum of 50 participants. Broad national representation is desired for this course, i.e., participation by at least eight or ten nations enhances the value of the comparative management aspects of the curriculum.

The Course is presented in English.

The course provides a series of lectures in three major areas: Environmental Factors; Quantitative and Economic Analysis; and Management Systems in the context of Strategy, Implementation, and Operations. The lectures are supplemented by small group discusssions and workshops which concentrate on the lecture topics and associated readings, problems, and cases. In the discussion groups, faculty members guide the interchange of ideas and are available to answer questions. Readings are assigned from within texts and supplemental material given to the participants to facilitate preparation for each lecture. Lecture outlines with additional suggested reading lists are provided. Occasional guest speakers are invited for special topics.

Early in the course, participants are requested to give brief presentations (by country) on their particular environmental situations, including such information as geographic factors, economic factors, social and cultural considerations, governmental and defense organizations, and unique management situations and/or problems. Throughout the course, the participants are encouraged to present and discuss information with respect to the defense management systems of their countries, and to examine how the management concepts and techniques discussed by both the Center faculty and the participants from other countries may be applied in their own situations. Comparative study by means of interaction among participants is considered to be an extremely valuable characteristic of the course.

During the course, the Center conducts field trips to selected military and commercial installations in the central California area. These trips provide an opportunity for the participants to receive special briefings on management techniques and problems, and to observe actual practices at the operating level.

In the second half of the course the general concepts of defense management are elaborated in detail during the examination of actual systems in financial, material and human resources management, and management information systems. At the end of the course a general review integrates the formal course material, special topics, and field trip experiences.

SENIOR INTERNATIONAL DEFENSE MANAGEMENT COURSE

Enrollment is restricted to military flag and general officers (grades 0-7 and above) and defense-related civilians of equivalent rank, except that for countries where the 0-6 grade is comparable to flag/general rank such officials may be enrolled on a waiver basis. Participation in past courses has been as high as 45

individuals from as many as 18 countries; a maximum of 50 participants can be accommodated.

The Course is presented in English.

The lecture, small discussion group, environmental seminar, case study and problem format and content described above for IDMC also applies, but compressed in time. Two or three guest speakers are included and a field trip is conducted.

FY 78 Schedule RESIDENT COURSES

78-1R	17 Oct 77-11 Nov 77	DMSC	4-week
78-2R	4 Jan 78-27 Jan 78	DMSC	4-week
78-3R	9 Jan 78-7Apr 78	IDMC	13-week
78-4R	30 Jan 78-24 Feb 78	DMSC	4-week
78-5R	27 Feb-23 Mar 78	DMSC	4-week
78-6R	13 Apr 78-20 Apr 78	F/G	1-week
78-7R	24 Apr 78-19 May 78	DMSC	4-week
78-8R	5 Jun 78-30 Jun 78	SIDMC	4-week
78-9R	10 Jul 78-4 Aug 78	DMSC	4-week
78-10R	7 Aug 78-1 Sep 78	DMSC	4-week
78-11R	7 Sep 78-14 Sep 78	F/G	1-week
78-12R	18 Sep 78-13 Oct 78	DMSC	4-week
78-13R	18 Sep 78-15 Dec 78	IDMC	13-week

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961-1965	1966-1970	1971-1975	1976	Total
Bachelor of Arts	....	....	....	180	389	349	1	919
B.S. in Aeronautical Engineering	73	212	212	181	61	15	....	754
B.S. in Chemistry	....	....	3	3	4	9	....	19
B.S. in Engineering Acoustics	....	....	....	....	....	3	3	6
B.S. in Electrical Engineering	156	292	232	520	308	186	14	1,708
B.S. in Engineering Science	....	....	....	....	141	135	....	276
B.S. in Environmental Science	....	....	....	12	....	....	....	12
B.S. in Management	....	....	....	53	1	....	....	54
B.S. in Mechanical Engineering	43	116	52	82	53	26	5	377
B.S. in Meteorology	16	104	77	108	49	29	....	383
B.S. in Operations Research	....	....	....	....	49	63	5	117
B.S. in Physics	....	15	36	75	35	19	2	182
B.S. in Systems Technology	....	....	....	....	....	....	4	4
Bachelor of Science	....	56	94	583	259	210	4	1,206
Total Baccalaureate Degrees	288	795	706	1,797	1,349	1,044	38	6,017
M.A. in National Security Affairs	....	....	....	....	....	23	33	56
M.S. in Aeronautical Engineering	....	....	....	40	115	224	50	429
M.S. in Applied Science	....	....	....	....	....	....	12	12
M.S. in Chemistry	....	....	16	5	32	16	....	69
M.S. in Computer Science	....	....	....	....	34	139	30	203
M.S. in Computer Systems Management	....	....	....	22	247	294	38	601
M.S. in Electrical Engineering	75	154	124	190	318	345	62	1,268
M.S. in Engineering Acoustics	....	....	....	....	13	37	11	61
M.S. in Management	....	....	....	406	633	964	137	2,140
M.S. in Material Science	....	....	....	5	9	....	....	14
M.S. in Mechanical Engineering	20	36	48	49	99	132	23	407
M.S. in Meteorology	23	19	40	53	53	126	7	321
M.S. in Oceanography	....	....	....	....	119	179	17	315
M.S. in Meteorology and Oceanography	....	....	....	....	....	....	4	4
M.S. in Operations Research	....	....	....	63	305	549	67	984
M.S. in Physics	....	25	104	135	124	102	16	506
M.S. in Systems Technology	....	....	....	....	....	19	26	45
Master of Science	....	17	65	102	56	25	1	266
Total Master's Degrees	118	251	397	1,070	2,157	3,174	534	7,701
Aeronautical Engineer	....	....	....	4	33	45	4	86
Electrical Engineer	....	....	....	....	40	64	9	113
Mechanical Engineer	....	....	....	....	6	25	5	36
Doctor of Philosophy	....	....	1	14	25	38	6	84
Total Degrees	406	1,046	1,104	2,885	3,610	4,390	596	14,037

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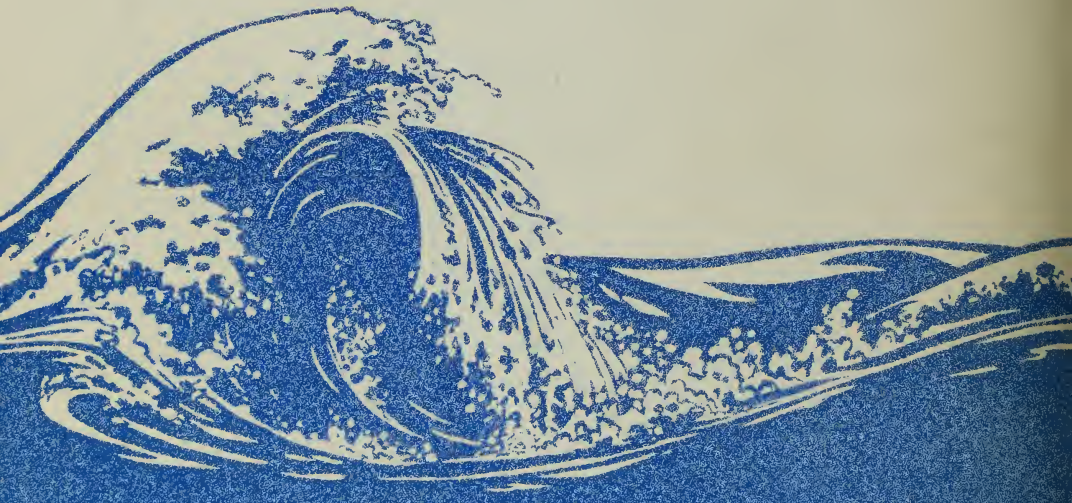


NAVAL POSTGRADUATE SCHOOL
EXCELLENCE THROUGH EDUCATION